NOTICE

All drawings located at the end of the document.

DRAFT

PHASE I RFI/RI WORK PLAN SOLAR EVAPORATION PONDS (OPERABLE UNIT NO. 3)

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
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ADMIN

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FIGURES (Appendix A)

PLATES

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LIST OF ACRONYMS

ARAR	Applicable, Relevant, and Appropriate Requirement
ASTM	American Society for Testing and Materials
CDH	Colorado Department of Health
CDI	Chronic Daily Intake
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environment Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
CM/S	Corrective Measures Study
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EG&G	EG&G Rocky Flats, Inc.
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FS	Feasibility Study
HSL	Hazardous Substance List
HSP	Health and Safety Plan
IAG	Interagency Agreement
IRIS	Integrated Risk Information System
mg/kg	Milligrams Per Kilogram

msl	Mean Sea Level
NCP	National Oil and Hazardous Substances Contingency Plan
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health Administration
OVA	Organic Vapor Analyzer
PID	Photo-Ionization Detector
PSC	Preliminary Site Characterization
PSZ	Perimeter Security Zone
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RFI	RCRA Facility Investigation
RFI/RI	RCA Feasibility Investigation/Remedial Investigation
RI/FS	Remedial Investigations and Feasibility Study
RI	Remedial Investigation
RME	Reasonable Maximum Estimate
RO	Reverse Osmosis
SAS	Special Analytical Services
SDI	Subchronic Daily Intake
SOP	Standard Operating Procedure
SWCS	Surface Water Control System
TDS	Total Dissolved Solids

USCS	Unified Soil Classification System
VOC	Volatile Organic Compound

Executive Summary

EXECUTIVE SUMMARY

This document presents the Work Plan for the Phase I RCRA Facility Investigation/ Remedial Investigation (RFI/RI) of the Solar Evaporation Ponds, which is a portion of Operable Unit 3, at the U. S. Department of Energy's (DOE) Rocky Flats Plant. This Phase I Work Plan has been prepared in accordance with the draft Interagency Agreement stipulated between DOE, the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Health (CDH). The purpose of the Phase I RFI/RI is to review previous data and further characterize contaminant sources and contaminated soils associated with this waste management unit.

This Phase I RFI/RI will focus on the Solar Evaporation Ponds as the most probable source of contaminants and, concurrently, will concentrate on the areal extent of contaminated soils in the vadose zone. Subsequent phases will focus on groundwater, air, biota, and appropriate corrective/remedial studies, proposed plans, designs, and actions. The primary technical objective of this plan is to characterize the nature and extent of contaminants in material associated with the Solar Evaporation Ponds that include: surficial soils and vadose zone, pond liquids and sediments, and pond liner and base course.

Following field investigations, a RFI/RI report will be prepared and will include a refined conceptual model, a Baseline Risk Assessment, and an Environmental Evaluation. The results of this report will be used as a decision tool for further investigations and to direct Interim Remedial Actions (IRA), if any are deemed appropriate. All responses to corrective action investigations and remedial design and construction will be implemented in accordance with the IAG and all appropriate guidance manuals.

Section 1--Introduction. This section is an explanation and overview of the Plan. Provided in this section are the purpose and objectives of the Plan, regulatory background information, and an outline of the technical objectives of the Plan.

Section 2--Site Description and Background. This section contains descriptions of the Solar Evaporation Ponds, associated French Drain System and their operational history and past and current use. Descriptions of site conditions are also provided that include the site geology, topography, surface water, groundwater, soil/vadose zone, and summary of previous investigations.

Section 3--Initial Evaluation. This section presents the site conceptual model, based on information and data provided in Section 2. Phase I data needs associated with the conceptual model, preliminary identification of remedial alternatives, and baseline risk assessment are presented.

Section 4--Field Investigation/Sampling Plan. This section contains the RFI/RI task descriptions and associated procedures and controls. The scope of the field investigations include:

- Sampling Solar Evaporation Pond liquids and sediments.

- Sampling liquids from accessible points in the French Drain System.

- Sampling soil/vadose zone material at 27 locations in the vicinity of the ponds.

- Sampling pond liner, base course, and underlying vadose materials at 28 locations distributed within the ponds. This task is held in obeyance until all the ponds have been emptied of liquid and sediment.

Section 5--Data Evaluation and Report. This section describes how the data collected during Phase I RFI/RI will be evaluated and includes a draft outline of the Phase I RFI/RI Report.

Section 6--Phase I RFI/RI Schedule. This section provides a timeframe and associated assumptions for the performance of the work presented in the Plan.

Section 7--Bibliography. This section lists the information sources that were used or are pertinent to preparation and production of the Plan.

The figures and tables called out in the text of this document appear in **Appendices A** and **B,** respectively. **Appendix C** contains the statistical summaries of data from background geochemical studies (Rockwell International, 1989). **Appendix D** contains the Baseline Risk Assessment Plan. Also, three oversized plates (referred to in Section 2) are included in plastic sleeves at the back of this document.

Section 1

Section 1

1.0 INTRODUCTION

As mentioned in the Executive Summary, this publication describes the Work Plan for the Phase I RFI/RI of the Solar Evaporation Ponds at the Rocky Flats Plant. The Rocky Flats Plant is a federally-owned nuclear weapons research, development, and production complex situated on 6,550 acres of federal property 16 miles northwest of downtown Denver, Colorado, (Figure 1-1). The Plant is managed and operated by EG&G Rocky Flats, Inc. (EG&G), a contractor to the DOE. The Solar Evaporation Ponds area is a portion of Operable Unit No. 3 at the Plant site.

1.1 PURPOSE AND OBJECTIVES

The purpose and objectives of the Phase I RFI/RI for the Solar Evaporation Ponds are derived primarily from the Draft Interagency Agreement (IAG), dated December 1989, between the Colorado Department of Health (CDH), the U.S. Environmental Protection Agency (EPA), and DOE, (DOE, 1989). Principal technical guidances for the RFI/RI are given in EPA "Interim Final RCRA Facility Investigation (RFI) Guidance," of May 1989, EPA "Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies (RI/FS) Under CERCLA," of October 1988, and Volumes I and II of the EPA "Risk Assessment Guidance for Superfund." As stated in the Executive Summary, the principal technical objective of this Phase I effort is to characterize the nature and extent of contamination in surficial soils and vadose zone materials, pond liquids and sediments, pond liner materials, and liquid from the French Drain System resulting from operation of the Solar Evaporation Ponds.

1.1.1 REGULATORY BACKGROUND

The IAG describes the general response processes under RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for the hazardous substance sites at the Rocky Flats Plant. These sites are grouped into 10 Operable Units.

There are several interim status RCRA units, including the Solar Evaporation Ponds, for which DOE has previously submitted Closure Plans. These closure units have been combined for the purpose of the IAG into Operable Unit 3, for which CDH will be the lead agency. For Operable Unit 3, the IAG directs DOE to amend and resubmit the source characterization plans of the Closure Plans as Phase I RFI/RI work plans.

The IAG stipulates a schedule for the Phase I RFI/RI for the Solar Evaporation Ponds to be completed and a final report issued in May 1992. The RFI/RI and all response activities performed by the DOE under the IAG are to be consistent with CERCLA, the National Oil and Hazardous Substances Contingency Plan (NCP), RCRA, applicable state law, and pertinent EPA guidance documents including those previously referenced. However, the primary source for the scope of the Phase I RFI/RI for the Solar Evaporation Ponds is the IAG, which formulates a phased approach for investigation and remedial action(s) tailored to the particular requirements of the Rocky Flats Plant. According to the IAG, the Phase I RFI/RI will determine the extent of source and soil contamination, identify additional work needed, and provide information for a Baseline Risk Assessment. Following the Phase I RFI/RI, the closure actions for Operable Unit 3 sites are to be conducted as Interim Remedial Action/ Interim Measures, if (or as) necessary.

Groundwater, surface water, air, and biota will be addressed in the Phase II RFI/RI. Other, subsequent Phase II activities are the Corrective Measures Study/Corrective and Remedial Action Proposed Plan, Corrective Action Decision/Record of Decision, Corrective Action/Remedial Design, and finally, Corrective/Remedial Action. The Phase II activities for the Solar Evaporation Ponds will be performed in conjunction with those for a number of other closure units located in the controlled area of the main plant facility.

1.1.2 TECHNICAL OBJECTIVES

The Phase I RFI/RI is to meet the following objectives:

- Define Solar Evaporation Ponds site physical characteristics.
- Define source(s) of contamination.
- Collect information to better understand the nature and extent of contaminants in soils and vadose zone.
- Collect information to better understand the fate and transport of contaminants in the soils and vadose zone.
- Provide information to support a baseline risk assessment to evaluate the need for interim remedial action.
- Provide information for DOE to further screen remedial actions associated with pond liquids, sediments, and liner materials.

The Phase I RFI/RI will involve preparing a Preliminary Site Characterization (PSC) and recommendations for a Phase II RFI/RI. Phase I will address the unit structures (pond liquids, sediments, and liner material) surficial soils and the vadose zone. Groundwater, air, surface water, and biota will be addressed in a later phase, or as part of plantwide investigations.

1.2 OVERVIEW OF WORK PLAN

This Work Plan is comprised mainly of a Field Investigation/Sampling Plan to be used as a guide for the Phase I investigations of the Solar Evaporation Ponds' liquids, sediments, surficial soils, and vadose zone. The Work Plan is formatted similar to the CERCLA guidance for remedial investigations (RIs), but with a scope limited to those media previously mentioned.

Existing available information about the Solar Evaporation Ponds unit and its site conditions are described in Section 2. The information, conclusions, and statements of fact presented in Section 2 are derived and summarized primarily from the Solar Evaporation Ponds Site Closure Plan (Rockwell International, 1988b), with some information from the "1989 Annual RCRA Ground-Water Monitoring Report" (EG&G, 1990f) and ongoing studies (EG&G, 1990g).

The initial site evaluation, preliminary identification of remedial alternatives and objectives, and Phase I data needs are presented in Section 3. The existing knowledge of the unit operations and site conditions, summarized in Section 2, is the basis for development of the site conceptual model. The conceptual model is used to define possible contaminant migration, particularly through the vadose zone in the vicinity of the Solar Evaporation Ponds and the French Drain System, and to identify important locations for soil/vadose zone sampling. Preliminary remedial alternatives for the unit are listed for the purpose of identifying data needs, and, for their evaluation at a later date. Also, a baseline risk assessment for the unit is presented. Finally, the Field Investigation/Sampling Plan data needs and objectives are presented. This information incorporates data collection requirements from the pathways in the conceptual model, potential remedial alternative design requirements, and risk assessment needs.

The Field Investigation/Sampling Plan is described in Section 4. This plan incorporates existing sitewide RI-related SOPs documented in the Sampling and Analysis Plan for the Rocky Flats Plant Environmental Restoration Program (DOE, 1990c). Section 5 provides details on how the data collected during the Phase I RFI/RI will be evaluated, and an annotated outline of the Phase I RFI/RI Report. Section 6 presents a schedule of the work to be performed, and Section 7 lists the references used to write this Work Plan.

Figures, tables, and related EG&G plans in preparation are provided in the appendices, and Plates 2-1, 2-2, and 2-3 are included in plastic sleeves at the end of the document.

Section 2

Section 2

2.0 SITE DESCRIPTION AND BACKGROUND

The Rocky Flats Plant is a government-owned and contractor-operated facility. It is administered by the DOE Albuquerque Operations Office and, as previously mentioned, is managed and operated by EG&G.

The facility produces metal components for nuclear weapons. Components are fabricated at the facility from plutonium, uranium, beryllium, and stainless steel. Other production activities include chemical recovery and purification of recyclable transuranic radionuclides, metal fabrication and assembly, and related quality control functions. Research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry and physics are also performed at the facility. Parts made at the plant are shipped elsewhere for final assembly (Rockwell International, 1988b, Vol. I, p. 4).

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver and 9 to 12 miles from the neighboring communities of Boulder, Broomfield, Golden, and Arvada (see Section 1, Figure 1-1). It is bounded on the north by State Highway 128, on the west by a parcel of land east of State Highway 93, on the south by a parcel of land north of State Highway 72, and on the east by Jefferson County Highway 17. Access to the plant is from an east access road exiting from Jefferson County Highway 17, and a west access road exiting from State Highway 93.

The facility is situated at an elevation of approximately 6,000 feet above mean sea level (msl). It is on the eastern edge of a geological bench known locally as Rocky Flats. The bench is approximately 5 miles wide and flanks the eastern edge of the foothills of the Rocky Mountains. The Plant consists of approximately 6,500 acres of federally-owned land in Sections 1 through 4, and Sections 9 through 15 of T2S, R70W, 6th Principal Meridian. Major buildings are located within the Plant security area of approximately 400 acres. The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 2-1).

2.1 HISTORY AND DESCRIPTION OF SOLAR EVAPORATION PONDS

2.1.1 INTRODUCTION

The Solar Evaporation Ponds have been used for waste management operations since approximately 1953. They have been used primarily to store and treat (by evaporation) low-level radioactive waste, mixed low-level radioactive waste, and hazardous waste. Management of non-radioactive and non-hazardous wastes has also taken place in the Solar Evaporation Ponds. Both the configuration and the uses of the Solar Evaporation Ponds have changed a number of times over the years. The following subsections describe the history, as well as the configurations and uses of the ponds.

2.1.2 CONSTRUCTION OF PONDS

2.1.2.1 The Original Solar Evaporation Pond

The original Solar Evaporation Pond consisted of a clay lined impoundment, constructed in December 1953, in the vicinity of the existing Pond 207-C. Figure 2-2 shows the approximate location of the original and existing ponds. Figure 2-3, a photograph taken in September 1956, also shows the original pond in relation to Solar Evaporation Pond 207-A. Figure 2-3 is an easterly view from the west side of the original Solar Evaporation Pond to Pond 207-A. As can be seen in Figures 2-2 and 2-3, the original pond consisted of two cells. These cells measured approximately 100 by 200 feet and 200 by 200 feet. The original Solar Evaporation Pond was operated with one and two cells until 1956, when its regular use was discontinued. Based upon aerial photographs, one of the two cells may have contained liquids one or more times since 1963. Aerial photographs also indicate that the location of the original pond was regraded in 1970, during the construction of Pond 207-C.

2.1.2.2 Solar Evaporation Pond 207-A

Pond 207-A was placed in service in August 1956. The original construction consisted of asphalt planking approximately 1/2-inch thick (Figure 2-4). Figure 2-5 depicts this installation. It is believed that Pond 207-A entered service shortly after construction. Pond 207-A is approximately 250 feet by 525 feet at the crest. Pond 207-A and the other Solar Evaporation Ponds are operated with a minimum freeboard of 2 feet. When operating at its maximum allowable level, the ponds' liquid covers an area of approximately 230 feet by 505 feet. This corresponds to a surface area of approximately 116,200 square feet, or approximately 3.0 acres. The maximum operating depth is approximately 7-1/2 feet (Rockwell International, 1988b, Vol. I, p. 21).

Pond 207-A was redesigned in November 1963 (Figure 2-6). At this time, the asphalt planking was replaced with asphaltic concrete. This asphaltic concrete lining is shown in Figure 2-6. The slopes of both the pond bottom and the pond sides were significantly modified. Based on these modifications, the bottom slope of the pond drained to a sump at the northeast end of the pond, and the side slopes, which had been 1:3.7, were changed to 1:2.

The side slopes of Pond 207-A were relined in the Fall of 1988 as a part of the closure operations. Prior to relining, the side slope of Pond 207-A had identifiable cracks. This relining consisted of a minimum of 1/8-inch thick, rubberized, crack-sealing material, laid over the side slopes of the pond. This relining was performed to minimize potential leakage from the pond in preparation for the transfer of pumped-back groundwater into the pond for evaporation. These activities were discussed with the CDH and the EPA, and proceeded as per agreements made with those agencies.

2.1.2.3 Solar Evaporation Ponds 207-B, North, Center, and South

Solar Evaporation Ponds 207-B North, Center, and South were placed in service in June 1960. These ponds were also originally lined with asphalt planking (Figure 2-7). Based upon available records, it appears that the 207-B ponds were relined shortly after being placed into service. The asphalt planking was covered with asphaltic concrete at 207-B South in November 1960, and at 207-B North and Center in August 1961 (Figure 2-8).

Ponds 207-B North, Center, and South are each approximately 180 feet by 253 feet at the crest. When operating at their maximum allowable level, the ponds' liquids cover areas of approximately 175 feet by 245 feet. This corresponds to surface areas of approximately 42,900 square feet each, or approximately 1 acre. Ponds 207-B North and Center have maximum operating depths of approximately 6-1/2 feet. Pond 207-B South has a maximum operating depth of approximately 5-1/2 feet (Rockwell International, 1988b, Vol. I, p. 21).

In 1977, the 207-B ponds were relined as a portion of a water management plan being implemented at the Rocky Flats Plant. The linings of Ponds 207-B Center and South were removed, bagged, cemented, and disposed of onsite. The lining of Pond 207-B North was not removed because it had held a minimal amount of sludge and residual radioactivity levels were not elevated. All of the 207-B ponds were relined, and Pond 207-B South received a synthetic Hypalon liner 45 millimeters thick (Figure 2-9). This pond was also provided with a leak detection system between the Hypalon liner and the asphalt concrete liner (Figure 2-10).

2.1.2.4 Solar Evaporation Pond 207-C

Solar Evaporation Pond 207-C (Figure 2-11) was placed in service in December 1970, and has an asphaltic concrete liner system. It is believed that Pond 207-C has not been relined since construction. The bottom of Pond 207-C slopes to the northeast, and details of the liner are provided in Figure 2-12. Pond 207-C was also provided with a leak detection system (see Figure 2-12).

Pond 207-C is approximately 160 feet by 250 feet at the crest. When operating at its maximum allowable level, the ponds' liquid covers an area of approximately 155 feet by 245 feet. This corresponds to a surface area of 38,000 square feet, or 0.87 acre. The pond has a depth of approximately 7 feet (Rockwell International, 1976; 1977a and 1978a).

2.1.2.5 Side Berm Repairs

Records and engineering drawings have been located which indicate that the exposed portions of the berms at the Solar Evaporation Ponds have been repaired and relined a number of times. These repairs were made because of cracks and damage that were identified in the exposed lining material. In April 1967, an unsuccessful attempt was made to fill the cracks on the side walls of the 207-B ponds with mastic. In November 1967, side wall cracks in the Pond 207-B North pond were successfully repaired with burlap and asphalt. In October 1968, the 207-B Center pond had its side walls successfully repaired with burlap and asphalt covering, and an additional coat of asphalt was applied to Ponds 207-B North and 207-B Center, respectively. Also, the side walls of Pond 207-B South were covered with burlap and asphalt in September 1970. The side walls of Ponds 207-B North and Center were covered with Petro-mat ® and hydraulic sealant in October 1971. Moreover, the side walls and bottoms of Ponds 207-B South and 207-B North were relined with Petro-mat ® and hydraulic sealant in October 1972 and September 1973, respectively.

2.1.2.6 Trenches and Sumps

Six interceptor trenches were constructed north of the Solar Evaporation Ponds to minimize natural seepage and pond leakage that might otherwise enter North Walnut Creek. This seepage and leakage contributed to elevated nitrate levels in the creek. The six interceptor trenches are shown on Figure 2-2.

Trenches 1 and 2 were installed in October 1971, Trench 3 in September 1972, Trenches 4 and 5 in April 1974, and Trench 6 in July 1974. Trench 5 drained by gravity to Trench 4. Water from Trench 4 was pumped to Trench 3, and Trench 3 returned the water to Pond 207-A. Trenches 1 and 2 pumped water uphill into sumps, after which the water was returned to Ponds 207-B North and 207-A. This system of trenches was largely successful in minimizing nitrate levels in North Walnut Creek (Blaha, 1990).

The trenches were in operation until the early 1980s when they were replaced by a more extensive French Drain System. The trenches and sumps that were not destroyed in related construction were abandoned in-place. Figure 2-13 shows a typical trench and French drain cross section (Blaha, 1990).

2.1.2.7 French Drain System

The French Drain System (see Figure 2-2) was installed as a part of the construction of the Perimeter Secured Zone (PSZ) at the Rocky Flats Plant. The PSZ construction destroyed some of the existing trenches, so a more extensive groundwater and seepage collection system was designed and constructed. Again, the purpose of the system was to minimize the seepage of waters into North Walnut Creek. The depths of the French drains range from approximately 1 to 27 feet below the ground surface, with typical depths of 4 to 16 feet (Rockwell International, 1988b, Vol. I, p. 16). A cross section through most of the French Drain System is similar to the cross section presented in Figure 2-13 for the trenches.

A portion of the French Drain System was designed to collect surface runoff in addition to groundwater and seepage. This portion of the system is present immediately below the Solar Evaporation Ponds and is identified in Figure 2-2 as segment D-D'. A cross section through this portion of the French Drain System is also provided in Figure 2-13.

One portion of the French Drain System was extended to the west to collect flow that daylights in the area from footing drains in the vicinity of Building 774. The portion of the French Drain System collecting this flow is identified on Figure 2-2 as segment E-E'.

Liquid collected in the French Drain System flows by gravity to the interceptor trench pump house (see Figure 2-2). The liquid from the pump house is then pumped to Pond 207-B North. The current amount of seepage collected by the French Drain System is estimated to be approximately 4 million gallons per year. The maximum amount of water collected in any 1 week was 700,000 gallons in June 1987 (Rockwell International, 1988b, Vol. I, p. 65).

2.1.3 PAST USE

The Solar Evaporation Ponds were constructed primarily to store and treat (by evaporation) low-level radioactive process wastes containing high nitrates, and treated acidic wastes containing aluminum hydroxide. During their use, these ponds are known to have received additional wastes such as sanitary sewage sludge, lithium metal, sodium nitrate, ferric chloride, lithium chloride, sulfuric acid, ammonium persulfates, hydrochloric acid, nitric acid, hexavalent chromium and cyanide solutions (Rockwell International, 1988b, Vol. I, p. 18).

Solvents and other organics have not been routinely discharged to the ponds. It was felt that organics would lead to algae growth which would diminish solar evaporation. However, low concentrations of solvents may have been present as a minor constituent in other aqueous wastes.

The use of the 207-B ponds changed in 1977. Until then, the three 207-B Solar Evaporation Ponds' cells had held process waste. However, in 1977 (after preliminary work was performed in 1976), the sludge from all of the 207-B ponds was removed. The liners of the 207-B Center and South ponds were also removed and disposed of offsite, and new liners were installed in these ponds. The 207-B North pond, had almost no sludge present and, therefore, did not have the liner removed; however, the existing liner was repaired. These activities were related to construction of the Reverse Osmosis (RO) facility and the related plant water recycle activities. Since the 1977 cleanout, the 207-B Solar Evaporation Ponds have not contained process waste (Rockwell International, 1988b, Vol. I, p. 19). These ponds have held, however, treated sanitary effluent, treated water from the RO facility, backwash (brine) from the RO facility, and contaminated groundwater pumped back to the Solar Evaporation Ponds from the French Drain System.

Pond 207-C was constructed to provide additional storage capacity and to enable the transfer and storage of liquids from the other ponds so that they could be taken out of service for repairs.

2.1.4 RECENT USE (SINCE 1986)

At present, Solar Evaporation Ponds 207-A, 207-B North, Center, and South, contain primarily pumped back contaminated groundwater. Pond 207-C contains primarily process waste. The routine placement of process wastes in the Solar Evaporation Ponds ceased in 1986.

Since 1986, the 207-B ponds have received pumped-back groundwater from the French Drain System. After Pond 207-B North reached capacity, this water was transferred to the other 207-B ponds. The 207-B ponds have slowly reached capacity since 1986. Pond 207-C has continued to store and treat process wastes. Since 1986, activities related to the Solar Evaporation Ponds have largely focused on Pond 207-A.

The removal of sludge from Pond 207-A began in 1986. This sludge was removed, thickened, and mixed with Portland cement to produce a material called Pondcrete, for disposal offsite. As sludge was being removed from Pond 207-A, the removal of water from the pond was also conducted by natural and forced evaporation via evaporators located in Building 374. Because of these efforts, Pond 207-A was essentially empty of materials in the summer of 1988. The last few hundreds of gallons of water were transferred to the 207-B ponds in order to allow inspection of the bottom and relining operations (described earlier) to be initiated. Pond 207-A was relined in 1988, but contaminated groundwater was not transferred from the 207-B ponds into this pond until March 1990. The transfer of water back into Pond 207-A was delayed due to a dispute with the EPA regarding the status of the Solar Evaporation Ponds (Blaha, 1990). Water was finally transferred into

Pond 207-A to prevent overtopping the other ponds with pumped-back groundwater.

2.1.5 RECENT INVESTIGATIONS

During preparation of closure plans in the summer of 1988, two sets of engineering drawings were located which presented conflicting information regarding the exact details of the Pond 207-B relining that took place in the early 1960s. One set of drawings (Figure 2-14) indicated that the 207-B ponds were provided with underdrains as a part of the relining activities, while a different set of drawings (see Figure 2-8) indicated that the ponds were relined without underdrains. Most of the manholes east of the 207-B ponds (see Figure 2-14) were present in the field, although personnel with definitive knowledge of the presence, or absence, of the underdrains could not be located. The drawings indicated that the manholes were provided with wooden covers, but one of the manholes had no cover and presented a safety hazard. Based upon this conflicting information, it was difficult to determine whether underdrains existed under the 207-B ponds.

Activities were conducted in the Fall of 1988 which determined that underdrains are probably not present under the 207-B ponds. These activities included locating all of the manholes, cleaning the manholes, and providing the manholes with suitable covers. Attempts were made to locate the northern-most manhole, but it was never identified (because according to the drawings, the manhole should have a wooden cover, it cannot be easily identified with a metal detector). The manhole is presumed not to exist, although it may, in fact, be present. Water was introduced into the line running north between the manholes to test whether collapses or blockages in the pipe were present. The water (approximately 500 gallons) was found to flow between the southern-most manhole (see southeast of Pond 207-B South Figure 2-8) and the manhole north of it, but did not discharge on the hillside north of the Solar Evaporation Ponds. This indicates either blockage or a sag in the pipe (sufficient to hold 500 gallons of water). However, the east lateral pipe, that runs from the Pond 207-B underdrains (that would have connected to the manholes), was not found. Based upon these activities, it was concluded that only some of the manholes, and the north-running line indicated in Figure 2-14, were constructed in the early 1960s and that the Pond 207-B underdrains were probably not constructed (Blaha, 1990).

2.2 SITE CONDITIONS

2.2.1 TOPOGRAPHY

The Rocky Flats Plant is located on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Rockwell International, 1988b, Vol. II, p. 3-3). The Colorado Piedmont ranges in elevation from 4000 feet msl on the east to 7000 feet msl on the west. The Piedmont merges to the east with the High Plains section of the Great Plains Province and is terminated abruptly on the west by the Front Range section of the Southern Rocky Mountain Province (Figure 2-15).

The Colorado Piedmont is an area of dissected topography and denudation where Tertiary strata underlying the High Plains have been almost completely removed. In a regional context, the Piedmont represents an old erosional surface along the eastern margin of the Rocky Mountains. It is underlain by gently dipping sedimentary rocks (Paleozoic to Cenozoic in age), which are abruptly upturned at the Front Range to form hogback ridges parallel to the mountain front. The Piedmont surface is broadly rolling and slopes gently to the east with a topographic relief of only several hundred feet. This relief is due to resistant bedrock units that locally rise above the surrounding landscape and to the presence of incised stream valleys. Major stream valleys which transect the Piedmont from west to east have their origin in the Front Range. Small local valleys have developed as tributaries to these major streams within the Piedmont. In the area of the Plant, a series of Quaternary pediments have been eroded across this gently rolling surface (Rockwell International, 1988b, Vol. II, p. 3-5).

The eastern margin of the Front Range, a few miles west of the Plant, is characterized by a narrow zone of hogback ridges and flatirons formed by steeply east-dipping Mesozoic strata (such as the Dakota Sandstone and the Fountain Formation). The Front Range reaches elevations of 12,000 to 14,000 feet msl 15 miles farther west.

Several pediments have been eroded across both hard and soft bedrock in the area of the Plant during the Quaternary (Rockwell International, 1988b, Vol. II, p. 3-5). The Rocky Flats pediment is the most extensive of these, forming a broad flat surface south of Coal Creek. From oldest to youngest, the three pre-Wisconsin deposits are the Rocky Flats Alluvium, the Verdos Alluvium and the Slocum Alluvium (Rockwell International, 1988b, Vol. II, p. 3-6). A series of Wisconsin and post-Wisconsin terrace deposits are present at lower elevations along streams that have incised the older pediments (east of the Plant).

The Rocky Flats Plant is located on a relatively flat surface of Rocky Flats Alluvium. The pediment surface and overlying alluvium (generally 10 to 50 feet thick, although the alluvium is as much as 100 feet thick west of the Plant) have been eroded by Walnut Creek on the north and Woman Creek on the south so that terraces along these streams range in height from 50 to 150 feet. The grade of the gently eastward-sloping, dissected Rocky Flats Alluvium surface varies from less than 1 percent at the Plant to approximately 2 percent just east of the Plant.

2.2.2 SURFACE WATER HYDROLOGY

Three ephemeral streams drain the Rocky Flats Plant and flow, generally, from west to east (Figure 2-16). Rock Creek, in the northwestern corner of the buffer zone, flows to the northeast, to its offsite confluence with Coal Creek.

Surface water flow from the Solar Evaporation Ponds area is toward North Walnut and South Walnut Creeks. A series of retention ponds known as the A-series ponds are located on North Walnut Creek, and a series of retention ponds known as the B-series ponds are located on South Walnut Creek (Figure 2-17). South Walnut Creek joins North Walnut Creek and an unnamed tributary coming from the landfill area, approximately 0.7 mile downstream of the eastern edge of the Plant security area, within the buffer zone. Walnut Creek then flows eastward approximately 1 mile into Great Western Reservoir.

2.2.2.1 North Walnut Creek

North Walnut Creek is an eastward flowing stream located north of the Solar Evaporation Ponds area. Surface runoff patterns (Figure 2-18) indicate flow entering the drainage from the Solar Evaporation Ponds area, the 700 Building Complex, the 300 Building Complex, and general surface runoff from the north and west sides of the Plant (Rockwell International, 1988b, Vol. II, p. 6-6). Due to the surface drainage pattern, any releases from the 700 and 300 areas would flow into North Walnut Creek above the retention ponds in the drainage located north of Pond 207-C (Rockwell International, 1988b, Vol. II, p. 6-6).

The A-series ponds on North Walnut Creek are designated A-1, A-2, A-3, and A-4, from west to east. Currently, Ponds A-1 and A-2 are used only for spill control, and North Walnut Creek stream flow is diverted around them through an underground pipe. Previously (until 1980), Ponds A-1 and A-2 were used for storage and evaporation of laundry water. Pond A-3 receives the North Walnut Creek stream flow and runoff from the northern portion of the Plant. Pond A-4 is designed for surface water control and for additional storage capacity for overflow from Pond A-3.

The discharges from the ponds are regularly monitored to document compliance with National Pollutant Discharge Elimination System (NPDES) permit requirements. In addition to NPDES monitoring requirements, all discharges are monitored for plutonium, americium, uranium, and tritium concentrations.

Surface water samples collected in August 1986, and in July and November 1987, were analyzed for the Hazardous Substance List (HSL) volatile organics, semivolatiles, pesticides/PCBs, major inorganic ions, metals and radionuclides (Rockwell International, 1988b, Vol. II, p. 6-9). Those analytes exceeding detection limits are presented in Tables 2-1 through 2-5 (surface water sample locations in the vicinity of the Solar Evaporation Ponds are shown on Figure 2-19).

Analytes with elevated concentrations in North Walnut Creek include manganese, thallium, iron, and total dissolved solids (TDS). Manganese exceeded water quality criteria in samples from surface water stations SW-18 and SW-17 (see Figure 2-19), and in samples collected from Ponds A-2 and A-3 (see Figure 2-17). Thallium exceeded water quality criteria in samples from surface water station SW-17, and iron exceeded water quality criteria in samples from surface water station SW-18. TDS exceeded the water quality criterion in samples collected from surface water station SW-17 and in samples collected from Ponds A-1 (see Figure 2-17), A-2, and A-3. The highest concentration of each of these analytes occurs in samples collected from Pond A-2, and may reflect residual contaminants from past usage to store laundry effluents (Rockwell International, 1988b, Vol. II, p. 6-17). In samples collected from Pond A-3, TDS and manganese exceeded the water quality criteria. However, discharges from this pond are in compliance with the conditions listed in the Plant's NPDES permit. Furthermore, at the most downgradient surface water station, SW-3 at Indiana Street (not shown on figures), all analyte concentrations are below the surface water quality criteria.

It was concluded that degradation of surface water quality in North Walnut Creek is due, in part, to recharge by alluvial groundwater in the vicinity of the Solar Evaporation Ponds, particularly at surface water station SW-17 (Rockwell International, 1988b, Vol. II, p. 6-19). However, containment of the flow by Pond A-3 and Pond A-4 with attendant reduction in analyte concentrations by natural processes, renders the quality of surface water leaving the Plant site acceptable with respect to the water quality criteria (Rockwell International, 1988b, Vol. II, p. 6-19).

2.2.2.2 South Walnut Creek

South Walnut Creek is an eastward flowing stream located to the east of the Solar Evaporation Ponds area. South Walnut Creek receives surface water runoff from the central portion of the Plant site. The Plant surface water drainage pattern (see Figure 2-18) indicates surface water drainage from the area south and southeast of the 207-B ponds flowing in a southeasterly direction toward South Walnut Creek. However, the drainage pattern also indicates runoff from the Mound and 903 Pad areas located to the south of the Solar Evaporation Ponds would contribute to flow in South Walnut Creek (Rockwell International, 1988b, Vol. II, p. 6-19).

The discussion of the 903 Pad, Mound, and East Trenches Areas Remedial Investigation Report (Rockwell International, 1987b) attributes most of the surface water contamination in South Walnut Creek to the Mound and 903 Pad areas. For this reason, it is not felt that the Solar Evaporation Ponds are contributing to South Walnut Creek contamination (Rockwell International, 1988b, Vol. II, p. 6-19).

2.2.3 GEOLOGY

2.2.3.1 Geologic and Stratigraphic History

The Rocky Flats Plant is located on the northwestern flank of the Denver Basin and is underlain by about 12,000 feet of Paleozoic and Mesozoic sedimentary rocks (Rockwell International, 1988b, Vol. II, p. 3-7). The Denver Basin is an asymmetric syncline that formed during the Late Cretaceous Laramide Orogeny. The western limb of the basin dips steeply to the east, and the eastern limb dips gently to the west (see Figure 2-15).

The geologic history of northeastern Colorado involves several episodes of mountain-building and oceanic transgression and regression, resulting in the deposition of thousands of feet of sedimentary rock on top of the Precambrian basement (Figure 2-20). More detailed descriptions of the units present onsite are provided in Subsections 2.2.3.2 and 2.2.3.3.

2.2.3.2 Plant Bedrock Geology

Bedrock units mapped at the Plant consist of the Laramie and Arapahoe Formations. These are shown in cross section in Figure 2-15. Because of the thickness (750 to 800 feet) and low permeability of the Upper Laramie Formation, it is considered to be the base of the hydrologic system which could be affected by Plant operations (Rockwell International, 1988b, Vol. II, p. 3-12). The scope of the Phase I RFI/RI for the Solar Evaporation Ponds includes the surficial soils and vadose zone but does not include the groundwater system. Therefore, a discussion of the deeper Laramie Formation is omitted from this Work Plan, but will be a subject for Phase II investigations. The Arapahoe Formation is described in the following paragraphs.

Arapahoe Formation. The Arapahoe Formation consists of fluvial claystones with interbedded lenticular sandstones and siltstones. Contacts between these lithologies are both sharp and gradational. The claystones are olive gray to dark gray, poorly indurated, silty, and contain up to 15 percent organic material. Weathering has penetrated from 10 to 40 feet into bedrock. The weathered claystone is light olive gray, blocky, slightly fractured, and has iron staining as mottles and along bedding planes and fractures (Rockwell International, 1988a, Vol. II, p. 3-15). The range of dips for these units in the Plant area are from 0-2 percent towards the east (EG&G, 1990g).

Sandstones in the Arapahoe Formation are light gray to yellowish gray, very fine- to medium-grained, with approximately 15 percent silt and clay. The sandstones are lenticular, discontinuous, and stratigraphically complex. The sand grains are subangular to subrounded and are predominantly quartzose, with 10 percent lithic fragments. The sandstones are poorly to moderately cemented and exhibit ripple marks, load casts, and planar, angular, and trough crossbedding. Cementation gradually increases with depth as weathering decreases. Cementing agents in the bedrock are predominantly argillaceous; however, locally and at shallow depth (typically up to about 10 feet), calcium carbonate (caliche) can dominate as the cementing agent. Silica cement is a minor constituent in the sandstone (EG&G, 1990g). Arapahoe Formation siltstones exhibit the same coloration, constituents, bedding characteristics, and sedimentary structures as the sandstones; however, they consist predominantly of silt-sized particles (Rockwell International, 1988a, Vol. II, p. 3-15).

Ongoing investigations of core samples within the sandstone units of the Arapahoe Formation may indicate the presence of a paleo-channel within these units (EG&G, 1990g). Figure 2-21 shows the approximate location of this interpreted paleo-channel in the vicinity of the Solar Evaporation Ponds area.

2.2.3.3 Plant Surficial Geology

There are six distinct unconsolidated units of Quaternary aged surficial materials in the vicinity of the Plant: Rocky Flats Alluvium, Verdos Alluvium, Slocum Alluvium, terrace alluviums, valley fill alluvium, and colluvium (Figure 2-22). The Solar Evaporation Ponds and French Drain System primarily reside within the boundary of the Rocky Flats Alluvium. Thus, a description of the Rocky Flats Alluvium is provided in this text (see Rockwell International, 1988b for details on the other sediments).

Rocky Flats Alluvium. The Rocky Flats Alluvium is topographically the highest and the oldest of the alluvial deposits. The alluvium unconformably overlies the Laramie and Arapahoe formations in the vicinity of the Plant. The deposit is a series of laterally coalescing alluvial fans deposited by streams (Rockwell International, 1988b, Vol. II, p. 3-16). The fans were deposited on an erosional surface cut into the bedrock units, including channelization around the hogbacks of the lower Laramie Formation.

The Rocky Flats Alluvium consists of sand, clay, silt, gravel, cobble, and occasional boulder deposits. Locally, the alluvium is cemented with calcium carbonate in the form of caliche. The color of the alluvium is pale to dark yellowish brown. The sands range from very fine-grained to medium-grained and poorly to moderately sorted. The thickness of the alluvium is variable due to deposition on an erosional surface and recent erosional processes. The alluvium is thickest to the west of the Plant, where less has been eroded, and thinnest to the east of the Plant (Rockwell International, 1988b, Vol. II, p. 3-16).

Various alluvial deposits occur topographically below the Rocky Flats Alluvium in the drainages and include the Verdos, Slocum, terrace, and valley fill alluviums and colluvium (see Figure 2-22). These deposits are primarily composed of reworked Rocky Flats Alluvium with the addition of some bedrock material.

2.2.4 GROUNDWATER HYDROLOGY

Groundwater occurs in surficial materials (Rocky Flats Alluvium, colluvium, valley fill alluvium, and disturbed ground) and in Arapahoe sandstones and claystones beneath the Solar Evaporation Ponds.

2.2.4.1 Groundwater System in Surficial Materials

Portions of surficial materials beneath the Solar Evaporation Ponds are unsaturated (Figures 2-23 and 2-24). The data on which these figures are based are provided in Tables 2-6 and 2-7. Where groundwater is present in surficial materials beneath the Solar Evaporation Ponds, it is either perched or under unconfined conditions (Rockwell International, 1988b, Vol. II, p. 5-10).

Recharge/Discharge Conditions. Recharge to the unconfined groundwater system occurs as infiltration of incident precipitation and, potentially, as leakage from the Solar Evaporation Ponds. In addition, groundwater within surficial materials flows laterally from the west into the Solar Evaporation Ponds area.

Discharge from the unconfined groundwater system occurs as evapotranspiration and seepage into creeks, ditches, and the groundwater collection system (French Drain System north of the Solar Evaporation Ponds). In addition, groundwater flows from the surficial groundwater system into the underlying bedrock groundwater system. Although this may occur to a limited extent throughout the Solar Evaporation Ponds area, it is probably more significant where sandstones of the Arapahoe Formation directly subcrop beneath the saturated surficial cover (Rockwell International, 1988b, Vol. II, p. 5-10).

The surficial groundwater flow system is believed to be quite dynamic, with large water level changes occurring in response to precipitation events and to stream and ditch flow. There are also seasonal variations in the saturated thicknesses of surficial materials. Chronological variations in saturated thickness are shown in the hydrographs found in Appendix B of the Solar Evaporation Ponds Closure Plan (Rockwell International, 1988b, Vol. II, p. 5-11).

Groundwater Flow. Groundwater flows toward the east and northeast beneath the Solar Evaporation Ponds area through the Rocky Flats Alluvium and disturbed ground. This flow is locally influenced by topography, the configuration of the top of bedrock (Figure 2-25), the French Drain System, and the Solar Evaporation Ponds, and potentially, the paleo-channel interpreted in ongoing studies.

Groundwater entering the Solar Evaporation Ponds area from the west seems to be affected by a bedrock high through the center of the area (see Figure 2-25) (Rockwell International, 1988b, Vol. II, p. 5-11). Groundwater is diverted north around this ridge, and much of the area south and east of the Solar Evaporation Ponds is unsaturated (see Figures 2-23 and 2-24). Groundwater moves downslope (north and east) from the Solar Evaporation Ponds toward North Walnut Creek through thin colluvial materials on the hillside. Large areas of unsaturated surficial materials also occur on this slope because of bedrock highs and the French Drain System (Rockwell International, 1988b, Vol. II, p. 5-12).

The French Drain System was installed in the hillside north of the Solar Evaporation Ponds (see Figure 2-2) sometime between June 1980 and April 1981. Depths of the drains range from approximately 1 to 27 feet below ground surface with a typical depth of 4 to 16 feet (Rockwell International, 1988b, Vol. II, p. 5-12). The seepage intercepted by the French Drain System flows by gravity into the interceptor trench pump house. The amount of pumpage from the pump house is estimated at 4 million gallons per year. Not all of this flow is groundwater seepage from the slope north of the Solar Evaporation Ponds (Rockwell International, 1988b, Vol. II, p. 5-12). Flow from the foundation drains in the 774 Building west of the Solar Evaporation Ponds area is also included, although this discrete volume has not been measured. The water collected in these foundation drains is then piped to the interceptor trench pump house, where it, and the groundwater collected by the French drains, are currently pumped to Pond 207-B North.

Hydraulic Conductivities. Hydraulic conductivity values were estimated for surficial materials from drawdown-recovery and pumping tests performed on the 1986 wells. Drawdown-recovery tests were analyzed using the methods of Bouwer and Rice (1976). Results of these tests are summarized in Table 2-8. Test data and analyses are presented in Appendix B of the Solar Evaporation Ponds Closure Plan (Rockwell International, 1988b, Vol. III). The hydraulic conductivity values calculated for surficial materials beneath the Solar Evaporation Ponds ranged from 4×10^{-8} centimeters per second (cm/s) to 9×10^{-6} cm/s.

2.2.4.2 Bedrock Groundwater Flow System

Groundwater is believed to occur in the Arapahoe Formation under unconfined and confined conditions based on site-specific conditions (Rockwell International, 1988b, Vol. II, p. 5-37).

Recharge Conditions. Recharge to the unconfined bedrock groundwater system occurs from infiltration of precipitation and potential leakage from the Solar Evaporation Ponds (Rockwell International, 1988b, Vol. II, p. 5-38). Recharge to the Arapahoe Formation sandstones occurs as infiltration to the sandstones at subcrops, and from downward leakage through the overlying claystones (Rockwell International, 1988b).

There is a variable downward gradient between groundwater in surficial materials and bedrock. The presence of a downward gradient has been demonstrated previously at the Plant (Rockwell International, 1988b, Vol. II, p. 5-38). Table 2-9 presents vertical hydraulic gradients calculated for alluvial/bedrock well pairs in the vicinity of the Solar Evaporation Ponds area (Plates 2-1 and 2-2). Calculated vertical gradients range from about 0.01 to 0.95. The well pair 24-86 and 23-86 (bedrock) does not yield a vertical gradient because Well 24-86 has always been dry. Vertical gradients between upper and lower sands in the Arapahoe Formation have not been calculated from Wells 31-86 (bedrock) and 32-86 (bedrock), because Well 31-86 has always been dry.

Groundwater Flow Directions. Groundwater flow within individual sandstones is from west to east at an average gradient of 0.09 ft/ft based on wells completed in the same sandstones at the 903 Pad, Mound, and East Trenches areas and on regional data (Rockwell International, 1988b, Vol. II, p. 5-40).

Hydraulic Conductivities. Hydraulic conductivity values for Arapahoe Formation sandstones were estimated from drawdown-recovery tests performed in 1986, slug tests performed in 1987, and packer tests performed in 1986 and 1987. Table 2-10 summarize the results of these tests. Data, analyses, and results of each test are provided in Appendix B of the Solar Evaporation Ponds Closure Plan (Rockwell International, 1988b, Vol. III).

The horizontal hydraulic conductivities calculated for sandstones vary from 1.12×10^{-8} cm/s to 3×10^{-6} cm/s with a geometric mean of 4.0×10^{-7} cm/s. This is in the range of the geometric mean of hydraulic conductivities calculated for siltstones (3.9×10^{-7} cm/s) and claystones (4.7×10^{-7} cm/s) found in the Denver Basin (Rockwell International, 1988b, Vol. II, p. 5-40).

The horizontal groundwater flow velocity for sandstone is 0.3 ft/year (Rockwell International, 1988b, Vol. II, p. 5-40). This is based upon a horizontal hydraulic conductivity of 4.0×10^{-7} cm/s (0.38 ft/year). The horizontal groundwater flow velocity for siltstones is 0.3 ft/year based upon a horizontal hydraulic conductivity of 3.9×10^{-7} cm/s (0.38 ft/year) and, for claystones, is 0.4 ft/year, based upon a hydraulic conductivity of 4.7×10^{-7} cm/s (0.45 ft/year). All calculations are based upon an average horizontal gradient of 0.09 ft/ft, and an assumed effective porosity of 0.1 (Rockwell International, 1988b, Vol. II, p. 5-40).

2.2.5 SOIL/VADOSE ZONE CHEMICAL AND RADIOLOGICAL CHARACTERIZATION

This subsection presents soil/vadose zone chemical and radiological data from investigations at the Solar Evaporation Ponds. The subsection begins with a summary of the characteristics of the Solar Evaporation Ponds' contents as this material is a potential source of contamination.

2.2.5.1 Solar Evaporation Pond Liquid and Sediment Characteristics

To characterize waste composition in the Solar Evaporation Ponds, numerous analyses of pond liquids and sludge have been conducted. Summaries of the laboratory results are presented in Tables 2-11 and 2-12, and detailed laboratory data are presented in Appendices 3 and 4 of the Solar Evaporation Pond Closure Plan (Rockwell International, 1988b, Vol. II, p. 4-1).

Liquids from Ponds 207-A and 207-C contain concentrations of nitrate, metals, and radionuclides that are approximately two orders of magnitude higher than those in Ponds 207-B North and Center (see Tables 2-11 and 2-12). Based on the analytical results reported in Table 2-10, Pond 207-A was, generally, more contaminated than Pond 207-C, except for plutonium and americium, which are approximately ten times higher in Pond 207-C. Plutonium and americium were not detected in Pond 207-B North.

2.2.5.2 Background Soil/Vadose Zone Characteristics

Information from two background studies is available for incorporation into this Phase I RFI/RI report on the Solar Evaporation Ponds area. The first evaluation of background soil/vadose zone characteristics was performed in 1986. This evaluation involved the collection of nine composite samples from the top 12 inches of soil from a plot in the Buffer Zone, west of the west spray field (Rockwell International, 1988b, Vol. II, p. 4-9). The exact locations of these samples could not be determined from available information; however, the results of that sampling event are presented in Table 2-13. As shown in Table 2-13, aluminum, total chromium, iron, lead, manganese, and zinc occur above detection limits. Also, uranium 233+234, uranium 238, and americium were found in levels above their respective counting uncertainty values. Although statistically limited, this background information was used as a comparative tool in interpreting the soil/vadose zone data collected in the 1986 to 1987 field investigation conducted in the vicinity of the Solar Evaporation Ponds. The results of that investigation are presented in Subsection 2.2.5.3, and all references to "background" in the discussion and data tables in that subsection are drawn on the background values established from the 1986 Buffer Zone samples.

The second evaluation of background soil/ vadose zone characteristics was performed in 1989, and involved a comprehensive collection of stream sediments, surficial alluvial and colluvial sediments, and bedrock material (Rockwell International, 1989). This collection of samples includes nine stream sediment samples from nine locations, 70 alluvial sediment samples from nine locations, 28 colluvial sediment samples from nine locations, and 21 bedrock samples

(17 weathered claystone and four weathered sandstone) from the nine colluvial sample locations. The sample locations are shown in Plate 3.

Detailed statistical methods, described in Subsection 2.2 of the Background Geochemical Report (Rockwell International, 1989, p. 2-3 through 2-9), were then applied to this soil data and statistical summaries were generated. These statistical summaries are presented in Appendix C of this document.

Comparison of 1986 and 1989 background soil/vadose zone values. The determination of a "background" value for a certain chemical parameter within a complex environment (such as soils) is difficult. Furthermore, such a determination requires a large amount of data to obtain a statistically significant background value that can be used as a screening tool to assess possible contamination by that chemical parameter.

In the 1986 Background Soil Investigation, limited samples were collected, and the establishment of a background value for a chemical parameter was taken as the upper range of values from those samples. For example, the background value for aluminum was taken as 9,140 mg/kg (see Table 2-13), which is the upper range of aluminum present in the nine composite samples. This value was then compared to the laboratory results for aluminum from soil borings in the Solar Evaporation Ponds area. If this reported aluminum value exceeded 9,140 mg/kg, it was reported as being above background, and was then tabulated (Tables 2-14 through 2-16).

In the 1989 Soil/Vadose Zone Investigation, many more samples were collected and statistical approaches were applied to the data. Basically, these statistical methods were used to generate an upper range of values specific for certain parameters. In this case, this upper range value was designated the upper tolerance limit. If a chemical parameter in a soil boring sample exceeds this tolerance limit, it is said to be above background (Rockwell International, 1989). Table 2-17 summarizes and contrasts the upper range of background values from the 1986 Buffer Zone Study, and the alluvial samples from the 1989 Background Geochemical Investigation. The alluvial samples were chosen for comparison because the large amount of samples (70) makes them the most statistically significant.

2.2.5.3 Results of Analysis of the 1986 Soil/Vadose Zone Samples

Soil samples were collected during the 1986 and 1987 field investigations conducted in the vicinity of the Solar Evaporation Ponds. The 1986 Field Investigation included split-spoon sampling of alluvium, bedrock, and the bedrock/alluvium contract in five boreholes. These five boreholes were later completed as Wells 18-86, 20-86, 22-86, 25-86, and 27-86 (see Plate 2-2). The procedures followed during the 1986 sampling program are described in the Draft Work Plan, Geological and Hydrological Site characterization (Rockwell International, 1986b, Vol. II, p. 4-9).

The 1987 field program included collection of soil samples from 16 boreholes, SP01-87 through SP16-87 (see Plate 2-2), two of which were completed as monitoring wells. Borehole SP08-87 was completed as Well 39-87, and SP16-87 as Well 56-87. The procedures followed during the 1987 field investigation are described in the Comprehensive Environmental Assessment and Response Program (CEARP), Phase 2, Rocky Flats Plant, Installation Generic Monitoring Plan (Rockwell International, 1988b, Vol. II, p. 4-11).

Soils were analyzed for a comprehensive suite of metals, organics, radionuclides, and other inorganics (Table 2-18). An examination of the soil analyses from the solar pond area indicates that the metals calcium, beryllium, cadmium, antimony, thallium, and possibly chromium and nickel are soil contaminants (Rockwell International, 1988b, Vol. II, p. 4-11). Although sodium and potassium concentrations are high in the liquid and sludge analyses from the ponds, elevated sodium and potassium concentrations were not detected in the analyzed soil samples. Except for probable laboratory contamination of the samples, volatile organic compounds (VOC) were not detected in the 1986 borehole samples from the Solar Evaporation Ponds area; however, low levels of 1,1-dichloroethane (1,1-DCA) chloroform ($CHCl_3$), 1,1,1-trichloroethane (1,1,1-TCA), trichloroethene (TCE), and total xylenes were detected in 1986 soil samples. Several soil samples also contained plutonium and, to a lesser extent, americium and uranium at levels above estimated background levels (Rockwell International, 1988b, Vol. II, p. 4-11). Nitrates are elevated in several of the analyzed soil samples. These general conclusions, including a discussion of laboratory contamination, are specifically addressed in this subsection.

Metals. Generally, metal concentrations in soil samples from the solar pond area were within two times estimated background levels as shown in Table 2-14. It is likely that natural variations in soil chemistry could explain variability in soil metal concentrations of a factor of two or even three. However, it becomes more likely that metal concentrations exceeding three times the estimated background, could be indicative of contamination (Rockwell International, 1988b, Vol. II, p. 4-13). Concentrations of metals exceeding the upper limit of the background range by a factor greater than three, are shown in Table 2-15.

Calcium exceeded three times the maximum background concentrations in a majority of the analyzed soil samples. Sludges in Pond 207-A contained calcium ranging from 20,000 to 50,000 milligrams per kilogram (mg/kg). Although a one-time analysis of Pond 207-A liquids indicates calcium was not detected, this datum is considered erroneous considering the high calcium content of the sludges and the elevated calcium concentration in Pond 207-B North which contains seepage/groundwater from beneath Pond 207-A. Leaching of calcium from these sludges along with leakage of high calcium liquids from the Solar Evaporation Ponds probably resulted in deposition of calcium in the soils beneath and hydraulically downgradient of the Solar Evaporation Ponds. High calcium is pervasive throughout these soils (Rockwell International, 1988b, Vol. II, p. 4-13).

As shown in Table 2-15, beryllium, cadmium, antimony, and thallium are at notably high concentrations, and are pervasive in the soils found in borehole SP16-87, located south of Pond 207-C. This borehole is in an area where the original Solar Evaporation Pond was located (Rockwell International, 1988b, Vol. II, p. 4-13). This is the only borehole where several metals occur throughout the depth at concentrations ranging from 10 to 1,000 times background. Therefore, it is likely that contaminated soils/waste from the original Solar Evaporation Pond is the material encountered in this borehole (Rockwell International, 1988b, Vol. II, p. 4-13).

Elevated cadmium concentrations occur in several soil samples from boreholes SP4-87 and SP5-87 adjacent to Pond 207-A (see Table 2-15). Concentrations in some soil samples were more than 10 times the estimated background levels. Considering cadmium was elevated in the Pond 207-A liquids and sludge, it is likely the observed cadmium concentrations represent soil contamination originating from the Solar Evaporation Ponds (Rockwell International, 1988b, Vol. II, p. 4-25).

As shown in Table 2-15, elevated chromium and nickel almost always occur in the same samples. These samples appear to be randomly distributed areally and vertically (Rockwell International, 1988b). One of the highest concentrations of chromium occurred in bedrock at a depth of 29 feet northeast of the Solar Evaporation Ponds and on the north side of the North Walnut Creek drainage (SP11-87). Also, soil samples occurring above and below samples with high concentrations of chromium and nickel are an order of magnitude lower in concentration. Although chromium and nickel occurred at elevated concentrations in Pond 207-A liquid and sludges, the absence of any spatial trend to the soils data, and their "suspicious" co-occurrence in the same samples (a possible laboratory error), does not support the conclusion that these metals originated from the Solar Evaporation Ponds (Rockwell International, 1988b, Vol. II, p. 4-25). Furthermore, chromium is not a groundwater contaminant, and nickel does not occur pervasively at elevated concentrations in groundwater. This also suggests that it is unlikely chromium and nickel migrated from the Solar Evaporation Ponds to the remote locations where they occur at high concentrations (Rockwell International, 1988b, Vol. II, p. 4-25).

There are no background data for strontium in soils at the Rocky Flats Plant; however, inspection of all the data collected for the Remedial Investigation Reports for the 903 Pad, Mound, East Trenches; and 881 Hillside (Rockwell International, 1988b, Vol. II, p. 4-26) show strontium concentrations to vary widely, but randomly, through the soils (Rockwell International, 1988b, Vol. II, p. 4-26). Concentrations ranged from <20 mg/kg to 196 mg/kg, but were generally less than 50 mg/kg at the Plant. Lindsay (1979) presented a range of 50 to 1,000 mg/kg, and average of 200 mg/kg for strontium in soils. The Brown Hazardous Waste Land Treatment Manual (1983) also presents a range of typical strontium values between 50 and 1,000 mg/kg, with an average of 200 mg/kg. Strontium concentrations in the soil samples from the Solar Evaporation Ponds area (and entire Plant area) were within these general ranges. Strontium concentrations in borehole samples from the Solar Evaporation Ponds area ranged from undetected to 250 mg/kg (Sample SP068711DH). As postulated in the 881 Hillside RI (Rockwell International, 1988b, Vol. II, p. 4-26), strontium above background levels in groundwater may be due to a release of strontium from the soils by the liquid waste disposed (or in this case, leakage from the Solar Evaporation Ponds).

Radionuclides. Radionuclides are analyzed by counting particles randomly emitted during radioactive decay. The rate of decay approaches an average rate for the material as the counting period increases. Because actual samples are counted for finite periods of time, there will always be uncertainty associated with any measured value. Radionuclide concentrations are thus reported as a measured value plus or minus a two standard deviation counting uncertainty (error term). This uncertainty is indicated in parentheses immediately following the measured value (see Table 2-16).

A determination that two radionuclide concentrations are different from each other requires a statistical analysis incorporating the uncertainty. However, radionuclide concentrations with error terms larger than their respective measured value are not considered statistically different from the background value shown in Table 2-16 because of the significant overlap of the probability distributions. If the measured value for a radionuclide falls within the background measured range, it is not considered to be above background levels regardless of the error term (Rockwell International, 1988b, Vol. II, p. 4-27). This is the basis for stating that a radionuclide concentration is within background ranges. Similarly, if the measured value minus the error term of a sample is greater than the measured value plus the error term for the upper limit of the background range, it can be considered to be statistically different from background. This leaves a range of measured values and error terms between these two extremes, where without a statistical analysis, it cannot be definitely stated whether the radionuclide concentration in the sample is different from background.

Uranium, plutonium, and americium concentrations in soil and core samples from the Solar Evaporation Ponds' borehole samples, generally met the above criteria for being below background concentrations (Rockwell International, 1988b, Vol. II, p. 4-27). Background data are not available for strontium 90 and cesium 137. Table 2-16 shows those samples in which radionuclide concentrations are above background levels. Only two soil samples had uranium 233+234, and only five soil, and three core samples, had uranium 238 concentrations above estimated background levels.

Nitrate. Examination of soil nitrate data (Table 2-19) indicates significantly elevated concentrations of nitrate (>200 mg/kg) form a northeast trending "plume" from borehole SP3-87 to SP14-87 and enveloping all intermediate boreholes except SP13-87 (i.e., SP4-87, SP5-87, SP6-87, SP8-87, and SP9-87) (see Plates 2-1 and 2-2). This "plume" direction is generally what is expected based on groundwater flow (Rockwell International, 1988b, Vol. II, p. 4-29) and may be related to the observed elevated nitrate concentration levels of the unconfined groundwater system (Figure 2-26).

The elevated concentrations occur at or beneath the water table or in the upper several feet of weathered bedrock. Although a water table was not identified during drilling of many of the boreholes into weathered bedrock, it is likely the weathered bedrock has been saturated with high nitrate water at times in the past (Rockwell International, 1988b, Vol. II, p. 4-29). Where the water table was encountered, it can be shown that a significant fraction of the nitrate in the soil is actually nitrate in the groundwater. The low concentrations of nitrate in the soils at SP13-87 (see Plate 2-2) may be due to its location on a bedrock high (see Figure 2-25) within the French Drain System. These two features have largely diverted nitrate-laden groundwater away from this location (Rockwell International, 1988b, Vol. II, p. 4-29). The high concentration of nitrate in the soils at SP14-87, which is just downgradient from the French Drain System (see Plate 2-2), may be residual nitrate contamination from historical releases from the Solar Evaporation Ponds and/or releases from the French Drain System during periods of overflow (Rockwell International, 1988b, Vol. II, p. 4-29).

From a historical perspective, soil nitrate concentrations in the early 1970s were an order of magnitude higher and generally located near the surface (Rockwell International, 1988b, Vol. II, p. 4-33). It is believed that the French Drain System has lowered the water table by allowing flushing of the soils near the surface by precipitation, and that the current nitrate releases to groundwater are less than in years past (Rockwell International, 1988b, Vol. II, p. 4-33).

Organic Contamination of Soil. The presence of HSL organics in soil samples at concentrations above detection limits are indicative of contamination provided that these organics are not present in laboratory blanks associated with the samples (Rockwell International, 1988b, Vol. II, p. 4-33). However, the presence of an HSL organic in a laboratory blank and sample, does not necessarily imply laboratory artifact if the concentration in the sample greatly exceeded the laboratory blank concentration. No analyses for laboratory blanks were included with the volatile organic analytical results for the 1987 boring soil samples (SP01-87 through SP16-87); therefore, it is not possible to evaluate whether the detected concentrations of methylene chloride, chloroform and 2-butanone are laboratory contaminants. However, inspection of the data in Table 2-20 indicates volatile organics are generally near or below detection limits. Analytical data for the core samples collected in 1986 indicated the presence of low concentrations of methylene chloride (MeCl), acetone, 1,1,-DCA, CHI_3, 2-Butanone (MEK), 1,1,1-TCA, TCE, toluene, and total xylenes. In most cases, VOCs are at estimated concentrations below detection limits and/or are present in the laboratory blanks. Low concentrations of VOCs also occur infrequently in the groundwater at the Solar Evaporation Ponds area. It appears that organic contamination, although possible, is not of major significance in the Solar Evaporation Ponds area (Rockwell International, 1988b, Vol. II, p. p. 4-33).

2.3 SUMMARY OF PREVIOUS SOLAR EVAPORATION POND INVESTIGATIONS

The following is a brief description of investigations, some of which have been discussed in greater detail in previous subsections of Section 2.

In 1970, Woodward-Clyde and Associates conducted an investigation of a potential landslide area north of Solar Evaporation Ponds 207-A, B, and C. Test holes were drilled to assist in the determination of subsoil and groundwater conditions and evaluate landslide risk: Ten test holes were drilled, and up to 6 feet of fill was encountered, underlain by 5 to 21 feet of clay, clayey gravel and sand, and weathered claystone. Also, free water was encountered in all test holes. The study concluded that the hillside below the ponds is a high risk area for landsliding, particularly with the probable addition of subsurface water flows from the ponds. In addition, it was recommended that a drainage system to remove subsurface water be installed.

Engineering Science, Inc. (1975) conducted an investigation concerning the problem of nitrate salts being transported from the area of 207 Solar Evaporation Ponds into North Walnut Creek. Ten holes were drilled along the north and east exterior of the Solar Evaporation Ponds and 21 additional test holes were drilled down the north slope of the ponds to determine the distribution of contaminated soil. These holes were terminated in bedrock and samples were collected for laboratory analysis. Findings from this study indicated that soils north and east of the Solar Evaporation Ponds were contaminated with nitrate and that these nitrates would continue to be leached from the contaminated soil and be transported to North Walnut Creek.

Another geotechnical investigation was conducted in 1984 by Geotechnical and Materials. Two exploratory test borings were drilled southeast and east of Pond 207-C to describe the subsurface conditions and recommend suitable types and depths of foundations for proposed new structures. These borings terminated approximately 14 feet below the existing grade in overburden materials. This study concluded that the proposed structures could be founded on spread footings, ring-wall, or mat foundations bearing on the in situ soils.

Hydro-Search, Inc. (1985) presented a hydrogeologic characterization of the Rocky Flats Plant. This report describes the hydrogeologic and groundwater quality conditions at the Plant based on existing data at the time. The groundwater monitoring system was described and evaluated, and recommendations were made for a new monitoring program.

In 1986, R. L. Henry (Rockwell International) submitted a report summarizing trends observed in the surface water monitoring at the Rocky Flats Plant. The report discusses the surface water control system (SWCS) completed in 1980, which is designed to divert flow around Plant site and collect surface runoff and store it temporarily for monitoring before discharge. Nonradioactive and radioactive trends in the surface water were also discussed.

Chen and Associates (Rockwell International, 1986a) prepared a closure plan for the Solar Evaporation Ponds. The plan describes the construction and operation procedures at the Solar Evaporation Ponds including past usage and size and volume of impoundments, waste inventory, and treatment and disposal of wastes. This closure plan was revised in 1987 (Rockwell International, 1988b, Vol. II, p. 2-9).

Twenty-one groundwater monitoring wells were installed in 1986 (see Plate 2-1). These wells were installed to characterize the hydrogeology in the Solar

Evaporation Ponds area and to evaluate if the Solar Evaporation Ponds were an imminent threat to the public or the environment. The work plan for the 1986 field program is presented in Rockwell International (1986b).

Chen and Associates (Rockwell International, 1986c) also prepared a preliminary prioritization of sites at the Rocky Flats Plant. The prioritization of sites was based on review of previous investigations and historical aerial photographs. The Solar Evaporation Ponds were considered a priority site.

In 1987, six monitor wells and 14 boreholes were drilled for characterization of the Solar Evaporation Ponds area. Results of this drilling program are presented in Sections 4 and 5 of this report.

In 1989, 33 monitoring wells were installed in the Solar Evaporation Ponds area by Rockwell International (Figure 2-27). During the drilling, some soil samples were collected for chemical and/or radiological analysis. However, the results are not yet available. Water levels and the results of groundwater sample analysis from these wells are reported in 1989 Annual RCRA Ground-Water Monitoring Report for Regulated Units at Rocky Flats Plant (EG&G, 1990f).

Existing geophysical data is limited to Seismic Reflection Data collected and interpreted by Ebasco Services and to borehole geophysical logs collected at Well 37-89BR. The details of Ebasco's interpretations, as well as the log profiles, can be found in the Solar Evaporation Ponds Closure Plan.

Section 3

Section 3

3.0 INITIAL EVALUATION

The site conceptual model, preliminary identification of remedial alternatives, and data needs are presented in this section. The site conceptual model is developed and based on the information presented in Section 2.0 and includes potential contaminant migration pathways from the Solar Evaporation Ponds to other media or receptors. The conceptual model is used to express current understanding of the nature and distribution of contaminants and potential contaminant pathways. Thus, the conceptual model can be used to help guide the RFI/RI investigations by testing current understandings.

The Phase I RFI/RI, in accordance with IAG, focuses on sources (e.g., Solar Evaporation Pond liquids, sediments, and liner material; surficial soils; and vadose zone materials) and, therefore, so does the conceptual model. However, to facilitate integration with the Phase II investigations, groundwater, air, and biota are included in this conceptual model, even though they will be the primary focus of Phase II.

3.1 SITE CONCEPTUAL MODEL

The major source of contaminants in the Solar Evaporation Ponds are the process fluids piped to the ponds for disposal. Fluids have been disposed of in the ponds since approximately 1953, and include the recent introduction of both treated sanitary liquids from the plant and liquids pumped back from the French Drain System. The liquids, sediments, and lining materials in the ponds are potential contaminant sources to the subsurface. Additional sources of contaminants in the Solar Evaporation Ponds area include potential leakage from existing and abandoned pipelines, drainage from footing drains from nearby building, and the old abandoned ponds in the vicinity of existing Pond 207-C.

The conceptual model is shown diagrammatically on Figure 3-1. The areas and materials that are included in this field sampling plan are in the center of the figure and involve:

- Ponds--liquids, sediments, lining materials, and base course materials
- Surficial soils
- Subsurface sediments of the vadose zone
- Perched water

Areas and materials that are not part of the field sampling plan, but are related as both sources and potential receptors, include air, surface water, biota, and groundwater. The interrelationships between those modes of contaminant transport and receptors are illustrated on Figure 3-2. Because they are related, a conceptual understanding of these modes is necessary to most effectively plan further investigations.

3.1.1 POND LIQUIDS AND SEDIMENTS

The ponds are conceptualized as mixing vessels, open to the atmosphere, in which solar evaporation increases the solids concentration to form a sediment of the mixture. The liquids and sediments in the ponds are undergoing changes in chemistry through the mixture of different cations, anions, and suspended solids. These reactions are complicated by the evaporative process combined with periodic dilution by rainfall and snowmelt, photochemical reactions, microbiological activity, and possible reaction with liner materials, which transform both the liquid and solid chemical composition into additional dissolved and complexed chemical constituents that can potentially be transported through infiltration and percolation into the vadose zone and groundwater system.

3.1.2 SURFICIAL SOILS

Soils in the vicinity of the Solar Evaporation Ponds are potentially contaminated with aerosols from the ponds, contaminants from groundwater seeps, and from other sources that may not be distinguishable from the Solar Evaporation Ponds. Contaminants in the surficial soils may be transported:

- Into the vadose zone and, ultimately, into the groundwater system via infiltration of precipitation and/or leakage from the Solar Evaporation Ponds

- Laterally, via surface runoff or as airborne fugitive dust

The principle parameters that control the aforementioned transport are the chemical nature of the contaminants, particulate size and occurrence, and rate of infiltration from precipitation and/or leakage from the Solar Evaporation Ponds.

3.1.3 VADOSE ZONE

The vadose zone is defined as the unsaturated subsurface depth interval from the surface to the water table, including perched groundwater zones and includes multiple geologic/lithologic units. It is commonly termed the unsaturated zone but in the Solar Evaporation Ponds Area, there may be perched groundwater intervals and leakage zones that are saturated. Descriptions of the saturated status of the sediments in the Solar Evaporation Ponds area indicate multiple saturated intervals within 40 feet of the ground surface which, in some cases, may be indicative of perched water. Exchanges between the vadose zone and groundwater involve both the maximum and minimum depth interval of the fluctuating groundwater level and the associated capillary fringe. The capillary fringe is a fluctuating depth interval of partial saturation that extends upward from the water table. It is included as part of the vadose zone. In the vadose zone, if leaks from the Solar Evaporation Ponds flow faster than they can percolate through the vadose zone, then the liquid will flow laterally through relatively more permeable materials or back to the surface. North of the Solar Evaporation Ponds, liquids have been observed on ground surface indicating leakage rate from pond(s) that is larger than the percolation capacity of the soil.

The environmental conditions of the ponds and the soils are similar through their exposure to atmospheric physicochemical conditions. These conditions can change abruptly in the subsurface. Approximately one-third of the surface is covered by ponds, buildings, and roads that restrict the movement of oxygen from the atmosphere into the subsurface. Leakage from the ponds contains nutrients for microbial activity. The changes associated with processes such as microbial activity can affect the fate and transport of contaminants in the vadose zone. For example, the fate and transport of both plutonium and americium are strongly dependent on the pH and oxidation reduction potential (Eh) (Dragun, 1988, p. 90 and 115). The pH and Eh measurements are two parameters that should be determined in the field.

The ionic state of some metals and radionuclides and the partical size of materials to which they are sorbed is thought to affect their transport in the subsurface. Laboratory and field investigations involving organic and inorganic ions indicate that the cationic ions (positively charged ions) and ionic complexes are removed or exchanged from solution much more effectively than anions (negatively charged ions). Also, recent research suggests that colloidal material is also a significant transport mechanism in the subsurface (Penrose et al., 1990).

3.1.4 UNCONFINED GROUNDWATER SYSTEM

Groundwater is believed to be present in the Rocky Flats Alluvium, colluvium, and subcropping sandstones in the vicinity of the Solar Evaporation Ponds under unconfined conditions. Depths to groundwater are expected to vary from 0 to 25 feet below ground surface depending on location, antecedent precipitation, and time of year. Groundwater flow is toward the northeast.

Recharge to the unconfined groundwater system in the vicinity of the Solar Evaporation Ponds is expected to be primarily: (1) from infiltrating precipitation, and (2) leakage from the Solar Evaporation Ponds. It is expected that contaminants in the liquids leaking from the pond(s) are carried downward through the vadose zone to the water table. Contaminants that have spread laterally in the vadose zone as described in Subsection 3.1.3 are subject to downward migration from the leaching affect of infiltrating precipitation.

3.1.5 SURFACE WATER AND SEDIMENTS

Surface water provides a pathway for transporting potential contaminants from the Solar Evaporation Pond area. North Walnut Creek may receive contaminates from the pond leakage via lateral groundwater flow, leaching from the vadose zone, and contaminated surficial soil transport by way of stormwater runoff. A series of dams, retention ponds, diversion structures, and ditches has been constructed at the Plant to control surface water, and to limit the potential for release of poor quality water. Some of the ponds are located in the drainages of North Walnut Creek. The creek and associated surface water control structures eventually lead to a reservoir, where the potential contaminants could be concentrated in related sediments.

The surface water system represents a potential route of exposure from ingestion/ absorption and direct contact exposure routes. If present, dissolved and suspended heavy metals, radionuclides, organics, and other contaminants may be released to, and transported by, the surface water system. Sediment from North Walnut Creek may currently act as an accumulation point for contaminants. These sediments may also be resuspended and diverted downstream during high flows.

To address source areas for potential pathways, surficial soil will be sampled to evaluate the nature and extent of contaminants.

3.1.6 AIR

As with surface water and sediments (described above), surficial, soils will be sampled to evaluate for possible contamination that could be transport as wind-blown dust.

Air transmission of potential soil contaminants from the Solar Evaporation Ponds may occur during the windy, dry periods of the year. Airborne release may also occur, to a limited extent, during site investigative activities if effective protective measures are not taken. Migration pathways correspond to local wind-flow patterns. Inhalation exposure is contingent on the proximity of receptor to the Solar Evaporation Pond area, although small particles, less than 10 microns in size, may be carried great distances. However, these particles will be well-dispersed and generally in low concentration.

3.1.7 BIOTA

Approximately two-thirds of the Solar Evaporation Pond unit is located on open ground, without irrigation. The remaining one-third of the area is highly developed and includes the ponds, buildings, and pavements. Surficial soils will be sampled to provide information to aid in evaluating potential impact to biota.

3.1.8 PATHWAYS AND RECEPTORS

The ultimate estimate of the fate and transport of contaminants in the Solar Evaporation Ponds area depends on the acquisition of the data to properly interpret the sources(s), release(s), transport mechanism(s) and exposure pathways. Under current and future land use scenarios at the Solar Evaporation Ponds, the primary pathways by which human receptors may potentially be exposed to contaminants include exposure to windblown aerosols and dust, direct contact with the surface water and sediments, ingestion and absorption of surface water and groundwater, direct ingestion of surficial soils, ingestion of vegetation grown in soil, and consumption of wildlife.

Environmental receptors (aquatic life, biota, and wildlife) could be exposed through the same routes (except groundwater). Environmental receptors include vegetation, cold water game fish, migratory waterfowl and terrestrial mammals.

3.2 PRELIMINARY IDENTIFICATION OF REMEDIAL ALTERNATIVES

The objective of the Phase I RFI/RI is to provide information and data required to verify and refine the site conceptual model, perform a baseline risk assessment, and screen alternative remedial actions. In order to focus the RFI/RI on specific goals, preliminary remedial alternatives are identified for closure of the Solar Evaporation Ponds.

Existing information on the Solar Evaporation Ponds indicates that a variety of aqueous wastes were disposed of in the ponds including uranium, transuranic elements (e.g., plutonium and americium), nitrates, metals, and volatile organics. Leakage from the ponds has resulted in contamination of the soil/vadose zone in the vicinity (areal location to be refined) of the ponds.

Remedial alternatives for the free pond liquids in Ponds 207-A, 207-B, and 207-C have been selected and are at various stages of implementation according to the Solar Evaporation Ponds Closure Plan (Rockwell International, 1988b, Vol. I, p.63). As closure of these ponds progresses, only 207-B South will remain open to receive water pumped back from the French Drain System. Eventually this water may be evaporated or treated in the onsite process waste water treatment plant. Figure 3-3 illustrates the current remedial action in use or proposed for free liquids remediation.

Sediment and sludge remedial action is also underway (Rockwell International, 1988b, Vol. I, p.73). Sludges from the ponds are being solidified by a process called "pond-creting." Disposal of sediments from the ponds will be based on their composition, which has not yet been determined (Rockwell International, 1988b, Vol. I, p. 39).

The remedial actions in progress or planned for the sediments and sludges in Ponds 207-A, 207-B (North Center, and South), and 207-C are illustrated in Figure 3-4. Already, many blocks of sludge have been pond-creted and stored on asphalt pads. Eventually, the blocks will be disposed of at an offsite facility such as the Nevada Test Site (Rockwell International, 1988b, Vol. I, p. 82).

The volume of the Solar Evaporation Pond liners for all three ponds, including underlying granular soils (base course materials), is estimated at 8,000 cubic yards (Rockwell International, 1988b, Vol. I, p.87). According to the Closure Plan (Rockwell International, 1988b, Vol. I, p. 87-88), liner material above permissible contaminant levels will be packaged and stored for offsite disposal. Liner material considered under the permissible contaminant level will be broken up and left onsite until capping and vegetation cover is placed. These alternatives, in addition to other potential alternatives, are illustrated on Figure 3-5.

Potential remedial actions to be considered for the soils and vadose zone materials (including the embankment soil) in the vicinity of the Solar Evaporation Ponds and French Drain System are illustrated in Figure 3-6. The volume of embankment soil is estimated to be 2,700 yd^3 (Rockwell International, 1988b, Vol. I, p. 94). The nature and extent of contaminants in surrounding surficial soils and vadose zone is not known well enough to provide reliable volume estimates of these materials on the basis of various levels of contamination.

3.3 BASELINE RISK ASSESSMENT PLAN

A baseline risk assessment will be prepared for the Solar Evaporation Ponds Area as part of the Phase I RFI/RI, to evaluate the potential threat to the public health and the environment for the no action alternative. The baseline risk assessment will provide the basis for determining whether or not interim and permanent corrective/remedial actions are necessary in the area (EPA, 1988). The assessment will include a public health evaluation and an environmental evaluation. The Baseline Risk Assessment Plan, which is presented in Appendix D of this Work Plan, addresses activities for the Environmental Restoration Program at the Rocky Flats Plant.

3.4 DATA NEEDS AND SAMPLING OBJECTIVES

For the Phase I RFI/RI, data are required for three general reasons:

- To verify and refine the site conceptual model
- To perform a baseline risk assessment
- To further screen remedial actions

The data needs identified in Table 3-1 support at least one or a combination of these reasons for collecting additional data.

Although much is known in general terms about the Solar Evaporation Ponds (see Section 2.0) such as their history, geology, and how they became contaminated, specific information is uncertain, or altogether unknown. What is known about the site is based on data that may not have been validated and is of uncertain quality. Also, some data may not have been validated to current standards for acceptable quality and reliability. Thus, the data to be collected in the Phase I RFI/RI are to fill in gaps of missing data or to supplement data of uncertain quality with respect to the three general reasons for collecting additional data.

3.4.1 DATA QUALITY OBJECTIVES

All liquid, pond sediment, soil/vadose zone, and subsurface water samples will be collected and analyzed in accordance with the ER Program Quality Assurance Project Plan (EG&G, 1990a), Standard Operating Procedures (SOPs) (EG&G, 1990c), Quality Assurance/Quality Control Plan (QA/QC) (EG&G, 1990b), and the Health and Safety Plan (EG&G, 1990d). The QA/QC Plan provides for chemical detection limits and data validation at levels appropriate for risk assessment purposes.

3.4.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Generally, remedial action(s) at the Solar Evaporation Ponds unit is required to comply with federal and state environmental laws and promulgated standards, requirements, criteria, and limitations that are legally applicable or relevant and appropriate under the circumstances presented by the release or threatened release of hazardous substances, pollutants, or contaminants. This is referred to as compliance with ARARs.

ARARs are being developed on a sitewide basis. Potential ARARs for groundwater have been developed on a preliminary basis for O.U. 2. ARARs for all media will be further developed in the near future, pursuant to the IAG, as a separate document.

Section 4

Section 4

4.0 FIELD INVESTIGATION/ SAMPLING PLAN

The overall objective of the Phase I RFI/RI is to better characterize the nature and extent of contaminants in specific media in and around the Solar Evaporation Ponds. Information on the nature and extent of contaminants is required for verification and refinement of the site conceptual model, to perform a baseline risk assessment, and for screening of remedial alternatives. Specific data needs are identified in Subsection 3.4

The scope of the Phase I RFI/RI is limited to the investigation of the following:

- Liquids and sediments in the Solar Evaporation Ponds
- Liquids from the French Drain System
- Soil/vadose zone materials in the vicinity of the Solar Evaporation Ponds and adjacent French Drain System
- Pond lining, base course materials, and vadose zone materials underlying the Solar Evaporation Ponds

The purpose of this section is to provide a detailed field sampling plan for collection of the data needs identified in Subsection 3.4. This Work Plan includes a task for investigating the pond liners, base course materials, and vadose zone materials directly underlying the Solar Evaporation Ponds. Because the ponds currently contain liquid, this task will be implemented as a subsequent activity of the Phase I investigations, after liquids and accumulated sediments have been removed from all of the ponds. The following tasks will be implemented during the Phase I RFI/RI of the Solar Evaporation Ponds:

- **Task 1--Existing Data Compilation**--Review and compilation of existing available facility data in the vicinity of the Solar Evaporation Ponds.

- **Task 2--Solar Evaporation Ponds Liquid and Sediment Investigations**--Samples of liquids and sediments from the Solar Evaporation Ponds will be collected and analyzed for chemical and radiological parameters. These liquid and sediment samples will be obtained at randomly selected locations within the ponds.

- **Task 3--French Drain System Liquid Investigations**--Samples of liquids from the French Drain System will be collected and analyzed for chemical and radiological parameters. These samples will be obtained from selected manholes and pump wells.

- **Task 4--Soil/Vadose Zone Investigations**--Subsurface borings will be performed at 27 selected locations. Samples of surficial soils and vadose zone materials will be collected and analyzed for chemical and radiological parameters.

- **Task 5--Solar Evaporation Ponds Liner, Base Course, and Vadose Zone Investigations**--Samples of pond liner, base course materials, and underlying vadose zone material will be collected and analyzed for chemical and radiological parameters after the ponds have been emptied of liquids and accumulated sediments. These samples will be obtained at 28 selected locations within the ponds and, also, at selected locations where liner damage is observed.

Task 1, Existing Data Compilation, should be implemented before Tasks 2, 3, 4, and 5. However, the Solar Evaporation Pond Liquids and Sediments Investigations (Task 2), French Drain System Liquid Investigation (Task 3), and Soil/Vadose Zone Investigations (Task 4), may be performed in any sequence without compromising the technical quality of the results. Solar Evaporation Pond Liner, Base Course, and Vadose Zone (underlying Solar Evaporation Ponds) Investigations (Task 5) will be implemented after liquids and accumulated sediments have been removed from all the ponds.

4.1 TASK 1--EXISTING DATA COMPILATION

Existing data compilation will consist of gathering additional available information (e.g. maps, drawings, and construction documents) on facilities associated with the Solar Evaporation Ponds and the French Drain System. Facilities such as buried pipelines and tanks may have an affect on contaminant migration and may be, or may have been, potential source(s) of contaminant release. Therefore, information on facility locations, past and present facility use, and the potential for contaminant release or documented releases may be required to adequately characterize the nature and extent of contaminants in and around the Solar Evaporation Ponds. This information is expected to be obtained from both published and unpublished documents. Also, an attempt to obtain additional specific information will be made through a further review of available engineering plans, reports, and through interviews with current and former employees.

Information on the existing facilities is also required for optimizing and finalizing borehole locations. The number and location of borings (described in a subsequent task) need to be flexible so that, based on the results of the data review, boring locations can be adjusted or additional borings added. Efforts will be taken to not duplicate other operable unit studies.

4.2 TASK 2--SOLAR EVAPORATION PONDS LIQUID AND SEDIMENT INVESTIGATIONS

The Solar Evaporation Ponds have received process liquids from Plant operations since approximately 1953 and, more recently, treated sanitary liquids from the Plant, and liquids pumped back from the French drains. Based on the data available, the existing liquids, bottom sediments, and liner materials of the Solar Evaporation Ponds are likely to contain contaminants. A range of alternative remedial activities to deal with these potentially contaminated materials is presented in the Closure Plans (Rockwell International, 1988b). To further evaluate these alternatives, it is necessary to sample the lining, liquids, and bottom sediments from the ponds. Pond 207-A had been emptied of liquid and sediment, and recently (March 1990) began receiving overflow water from Pond 207-B (North). It is, therefore, unlikely that sediments have formed in Pond 207-A, and sediment sampling will not be attempted in this pond. This subsection describes the objectives and the procedures for sampling pond liquids and sediments. Sampling of the pond lining and base course is described in Subsection 4.3.

The objective of the Solar Evaporation Ponds Liquid and Sediment Investigation is to better describe the nature and extent of contaminated materials remaining within the ponds. The thickness of sediments in the ponds will be measured at a limited number of locations in Ponds 207-C and 207-B, so that sediment volume can be estimated. Also, samples of pond liquids and sediment will be collected at a limited number of locations for analysis so that the chemical and radiological nature of these materials can be evaluated. This information is necessary to further screen the remedial alternatives proposed. Inputs into the ponds may be dynamic and transient. Also, within the ponds, various reactions are occurring in addition to evaporation and sedimentation. Thus, pond liquid and, to a lesser degree, sediment samples may only be representative of present conditions. Therefore, a limited number of samples will be collected in Phase I. Additional samples may be required in subsequent phases and for closure.

4.2.1 SURFACE CONTAMINANT SURVEY

Initial surface contaminant surveys to establish health and safety requirements will be performed before undertaking other field activities as required by 29 CFR 1910.120 (OSHA). These surveys will be performed to identify areas where hazardous chemical or radionuclide contaminants are present. The surface contaminant survey for liquid and sediment sampling activities is limited to an area outside the pond perimeter to an arbitrary distance of about 25 feet from the pond. Additional surveys may be required at staging areas established near the ponds for the sampling program.

The hazardous chemical screening survey will be performed with direct reading field instruments such as an organic vapor analyzer (OVA) or photo-ionization detector (PID) to detect volatile organics. Draeger tubes will be used to detect specific inorganics of concern such as cyanide or chlorine.

Radiation screening surveys will be used to establish areas of gross contamination, which could potentially impact field personnel health and safety practices. The radiation screening surveys will be conducted using portable beta-gamma count rate meters with a gamma scintillation probe. Any areas with significantly elevated count rates will be surveyed with a direct reading dose rate meter to establish potential exposure rates to field personnel. Detection limits and calibration for those devices should be in accordance with the QA/QC and Health and Safety Plans (EG&G 1990b and 1990d, respectively).

Areas of potential concern will be documented, assigned identification numbers, and marked with spray paint. Instrument readings (volatile organic or hazardous inorganic concentration levels or radiation exposure rates) will be recorded in a field logbook. Based on the radiation screening surveys, appropriate levels of personnel protection equipment and clothing will be established in accordance with OSHA requirements and the Health and Safety Plan (EG&G, 1990d).

4.2.2 SAMPLING LOCATIONS

Sample locations will be randomly chosen from a variable size 100-node grid. The sampling grid has been sized to nominally fit within the pond areas such that two sampling grids will fit in Pond 207-A and one grid within each of Ponds 207-B (North), 207-B (Center), 207-B (South), and 207-C, for a total of six grid applications as shown in Figure 4-1. Two sampling locations have been randomly selected for each of the six grid applications. As a result, liquid and sediment samples will be obtained from each of Ponds 207-B (North), 207-B (Center), 207-B (South), and 207-C at two locations, while Pond 207-A will be sampled at four locations for liquids only, as shown in Figure 4-2. Survey techniques will be used to position samples on the ponds at the locations shown on Figure 4-2.

4.2.3 SAMPLING METHODS

Information compiled from previous investigations of the Solar Evaporation Ponds area indicates that Pond 207-C contains the highest concentration of radionuclides, while Pond 207-B (North, Central and, South) has primarily received treated sanitary liquids and liquids pumped back from the French Drain System. All ponds, which contain liquids at the time the liquid and sediment sampling program is initiated in the field, will be sampled.

Pond liquid samples should be taken before the sediment sample is collected to avoid resuspending the sediments. Both pond liquid and sediment sampling will be performed from a floating work platform. Horizontal survey methods will be used to position the floating work platform at the sampling locations. Liquid samples will be taken using a teflon bailer with a bottom ball-valve. At each location, two vertically composited liquid samples shall be collected. One sample will be unfiltered and the other will be filtered (refer to Subsection 4.6 for sample handling procedures).

Sediment sampling will be performed using the piston-type sediment sampler shown in Figure 4-3. This sampler is preferred because it has previously worked well in soft sediments and it is not likely to penetrate or otherwise damage the pond lining. The sampler can also be used to obtain estimates of pond sediment thickness. The sampler body is constructed of clear acrylic pipe, graduated in 0.1-foot increments so that field personnel can make a visual estimate of the recovered sediment thickness. The procedure for sediment sampling and for estimating sediment thickness is described in the following paragraph.

The sediment sampler will be decontaminated before the first use, and before each subsequent sample is collected as described in Subsection 4.6. Once positioned at the sampling location, the piston will be preset at the bottom of the sampler. A minimum of two technicians will be required for sediment sampling. The sampling technician will lower the sampler into the pond, while the assisting technician records the depths to the top of the sediment and to the pond liner. The sampler will be lowered slowly to allow the sampling technician to feel the resistance to penetration as the sampler encounters the sediments. When resistance is first encountered, the water level on the sampler will be recorded, then the sampler will be slowly advanced into the sediments while the piston is retracted up the sampler. When the bottom of the pond is reached, or other moderate resistance is encountered (i.e., such that the sampler does not continue downward under its own weight plus a downward force of approximately 15 pounds after compensating for sampler buoyancy), the sampling technician will cease penetration and measure the water level on the sampler. Extreme care must be taken so as not to damage or penetrate the pond liner, particularly where a geomembrane lining is present. The sampler will then be slowly raised vertically from the pond and the bottom end of the sampler will be capped with a close-fitting acrylic cap to limit loss of core. The length of core in the sampler will be measured and the core placed directly into decontaminated sample jars (Refer to Subsection 4.6 for a description of sample handling and analysis).

If there is no apparent resistance from the sediments as the piston core sampler is lowered, the sampling team will move to a new location approximately 3 feet from the previous location, and reattempt sampling using the following technique. First, the sampler will be lowered slowly to approximately 6 inches above the pond bottom, as determined from the previous sampling attempt. Then, the sampling technician will slowly advance the sampler, while the piston is simultaneously retracted up the sampler. When the bottom of the pond is reached, or other moderate resistance is encountered (as previously described), the technician will cease penetration, measure the water level on the sampler, and recover the sampler. The length of core in the sampler, if any, will be measured and the core placed directly into decontaminated sample jars.

Liquid and sediment sampling will be performed in accordance with EG&G SOPs. Details on decontamination procedures, sample handling procedures, analysis, screening, and sample designation are provided in Subsection 4.6.

4.3 TASK 3--FRENCH DRAIN SYSTEM LIQUID INVESTIGATION

The French Drain System intercepts groundwater flowing in the unconfined groundwater system. The intercepted groundwater is then pumped into Pond 207-B

(North). The potential sources of groundwater reaching the French Drain System include:

- Leakage from the Solar Evaporation Pond(s)
- Groundwater flowing laterally in the unconfined groundwater system
- Infiltration of precipitation
- Drainage from footing drains (e.g., Building 774 drain)

To further screen alternatives for closure of the French drain area, it is necessary to collect liquid samples from the French Drain System. This subsection describes the objectives and procedures for sampling these liquids.

The objective of the French Drain System liquid sampling is to collect information that can be used to evaluate contaminants occurring in the groundwater intercepted by the French Drain System and, ultimately, differentiate the potential sources. Liquid samples will be collected from selected manholes and pump wells associated with the French Drain System for chemical and radiological analysis.

4.3.1 SURFACE CONTAMINANT SURVEY

Surface contaminant surveys for French Drain System liquid investigations will be performed in accordance with Subsection 4.2.1 herein, except that the survey area will be limited to an approximate 25-foot-diameter area centered at each sampling location.

4.3.2 SAMPLING LOCATIONS

Liquid samples from the French Drain System will be obtained at the following locations (see Figure 2-2):

- The pump well at the western extent of the French Drain System

- The manhole located along French drain segment D-D' as shown on Figures 2-2, immediately north of Pond 207-A

- The interceptor trench pump house at the northern extent of the French Drain System

- Access points as identified in Task 1 and as selected by the site hydrogeologist

4.3.3 SAMPLING METHODS

Liquid samples will be collected using a Teflon bailer with a bottom ball-valve. At each location, two vertically composite liquid samples shall be collected. One sample will be unfiltered and the other will be filtered (refer to Subsection 4.6 for sample handling procedures).

Liquid sampling will be performed in accordance with EG&G SOPs. Details on decontamination procedures, sample handling procedures, analysis, and sample designation are provided in Subsection 4.6.

4.4 TASK 4--SOIL/VADOSE ZONE INVESTIGATIONS

The objective of the Soil/Vadose Zone Investigations is to collect representative samples of surficial soils and vadose zone material for chemical, radiological, and in some cases physical analysis so that a baseline risk assessment can be performed, to refine the conceptual model, to better understand the nature and extent of contaminants in the vadose zone, and to further screen remedial actions. Further characterization of the nature and extent of contaminants in the surficial soils and the vadose zone is required for the areas in the vicinity of the Solar Evaporation Ponds and French drains. Specific sites for sampling have been selected based on available information. Surficial soil samples will be collected for chemical and radiological analysis. Continuous core samples of vadose zone material will be collected for development of detailed geologic logs and for physical, chemical, and radiologic analysis of selected samples.

4.4.1 SURFACE CONTAMINANT SURVEY

A surface contaminant survey will be performed in accordance with Subsection 4.2.1 herein, except that the survey area will be limited to an approximate 150-foot-diameter area centered at each boring location.

4.4.2 SAMPLING LOCATIONS

A total of 27 soil/vadose zone borings will be drilled in the vicinity of Ponds 207-A, 207-B (North, Central, and South), 207-C, and in the property just north of the RCRA Waste Management Area. These borings are in addition to the 28 boring locations within the pond boundary, as described in Subsection 4.5 (Task 5). The location of the 27 proposed borings, as well as existing monitoring wells and piezometers, is shown in Figure 4-4. Surficial Soils Investigations will precede the boring locations where ground surface is soil. A description of the boring locations along with the basis for choosing the boring locations is summarized in Table 4-1.

4.4.3 SAMPLING METHOD

Surficial soil sampling will precede the vadose zone borings at all locations except where pavement or other man-made surfaces exist. The procedure for surficial soil sampling is as follows: a 1-foot square template will be placed on the ground surface centered on the boring location; surface soils within the template will be excavated to a depth of approximately 1/2-inch and composited for the first sample; a long-handled spoon or a trowel, or other similar tool, will be used to excavate the first sample; finally, the sample will be placed directly into sample jars. This sample will represent potentially immobile contamination from aerosol deposition.

The second surficial soil sample will consist of soils excavated from between a 1/2-inch depth to approximately a 6-inch depth. Sampling will be performed using an agricultural plug-type soil sampler. Soil plugs will be collected from the four inside corners and the center of the template area over the target depth range. If the soils are not amendable to this sampling technique, then the sample will be excavated using a trowel or long-handled spoon. This sample will represent the more mobile, but adsorbed, fraction of the aerosol deposition, and the subsequent dissolution of potential contamination.

One of the surficial sampling locations will be randomly selected for a duplicate surficial soil sample. The duplicate sample will be collected immediately adjacent to the original surficial sample. All surficial soil sampling equipment, use, procedures, and decontamination will be in accordance with EG&G SOPs (refer to Subsection 4.6).

The initial depth of the vadose zone borings will be determined by the final depth of the previous surficial soil investigation. The vadose zone boreholes will be installed using a truck-mounted and/or a skid- or trailer-mounted hollow-stem auger drilling rig, as may be required for access. Samples will be collected for geologic description for the entire borehole depth at each location. Samples will be continuously dry-cored using a 5-foot-long split-barrel sampler in the lead auger. Drilling, sampling, and borehole logging methods will be in accordance with EG&G SOPs. All cuttings and excess sample material obtained from the borings will be placed directly into new, first quality 55-gallon drums in accordance with EG&G SOPs (EG&G, 1990c) and U.S. Department of Transportation (DOT)-17H requirements for storage and disposal by

EG&G. The boreholes will be abandoned with a bentonite slurry in accordance with the SOPs (EG&G, 1990c, in preparation).

Discrete soil and rock samples will be submitted for laboratory chemical, physical, and radiological analyses (refer to Subsection 4.6 for analyte list). These samples will be selected from the continuous core at a minimum of 5-foot intervals from near the ground surface to the top of the unweathered Arapahoe Formation. Additional samples will be selected at changes in lithology and from zones that have indications of contamination as determined from visual inspection of the sample or field instrument screening for organics and radionuclides. Sample selection will be performed by site personnel in accordance with EG&G SOPs.

Estimated target drilling depths for the vadose zone borings are presented in Table 4-2. The estimated target depths are provided for purposes of evaluating the approximate investigation work scope; drilling will be terminated in the field at depths corresponding to the top of unweathered Arapahoe Formation as determined in the field by the site hydrogeologist. The weathered Arapahoe Formation, for the purpose of this investigation, is characterized as the upper formation materials which, because of natural weathering processes, are expected to have a higher hydraulic conductivity relative to immediately lower portions of the formation. The portion of the weathered formation having higher hydraulic conductivities is assumed to be the upper 10 feet of the formation for all of the vadose zone borings. This assumption is based on recent geologic studies at the site that indicate that the depth of weathering in the Arapahoe Formation, as determined from depth of iron oxide staining, ranges from 10 to 40 feet at the site (EG&G, 1988b and EG&G, 1990e). In addition, if free subsurface water is encountered, a discrete water sample will be collected for chemical and radiological analyses. If free subsurface water is encountered as indicated by saturated cuttings or core, the advancement of the drilling augers will be halted for a period of up to 30 minutes or as determined by the site hydrogeologist. During this period, the site hydrogeologist will determine whether there is a sufficient quantity of water to allow sampling. An attempt will be made to collect enough volume for both filtered and unfiltered samples (refer to Subsection 4.6 for sample analysis and handling). Determination of the water quantity will be performed by measuring the rise of the water within the augers using a decontaminated water-level indicator deployed from the ground surface. If sufficient water is available for sampling, then the site hydrogeologist will sample the water through the hollow-stem augers using a Teflon bailer with a ball-valve. If the water quantity is insufficient, the boring will continue to be advanced to the next sample depth, until there is either evidence of sufficient water for sampling or until the target borehole termination depth is reached, whichever is the lesser depth. Borehole water sampling will be performed in accordance with EG&G SOPs.

4.5 TASK 5--SOLAR EVAPORATION PONDS LINER, BASE COURSE, AND UNDERLYING VADOSE ZONE INVESTIGATIONS

Data on the nature and extent of contamination in pond liners and underlying base course and vadose zone materials will be collected under this task. The objective of the Solar Evaporation Ponds Liner, Base Course, and Underlying Vadose Zone Investigations is to characterize the nature and extent of contaminated materials (chemical and radiological) and to refine the conceptual model so that remedial alternatives can be further screened. Also, information from the vadose zone sampling will be used for the baseline risk assessment. Samples of the liner, base course, and underlying vadose zone materials will be collected at 28 selected locations and at locations where the liner may have been leaking (liner and base course samples only). The samples will only be collected after the liquids and sediments have been removed from all of the Solar Evaporation Ponds.

4.5.1 SURFACE CONTAMINANT SURVEY

Surface contaminant surveys for this investigation will be performed in accordance with Subsection 4.2.1 herein, except that the areas surveyed will be limited to the entire bottom area of the emptied ponds.

4.5.2 SAMPLING LOCATIONS

Liner, base course, and vadose zone samples will be obtained at 28 evenly distributed (areally) locations (Figure 4-5) and at locations of possible liner damage (liner and base course material only). Vadose zone samples underlying the ponds will be obtained from continuous core samples taken with a hollow-stem auger drill as described previously in Subsection 4.4 (Task 4).

For the individual ponds, the following number of locations (Figure 4-5) have been selected for liner, base course, and underlying vadose zone material sampling:

- Five sample locations each for Ponds 207-B(North), 207-B(Center), and 207-B(South)

- Eight sample locations Pond 207-A

A maximum of six samples per pond may be taken at locations of potential liner damage if, based on visual inspection of the pond liner bottom, cracks or other damage is evident that may have allowed leakage from the pond(s). These samples, if any, are in addition to those taken at the 28 random locations.

4.5.3 SAMPLING METHODS

Pond liner and base course material sampling. Pond liners will be visually inspected for cracks, broken areas or other forms of damage. Damaged areas which may have allowed infiltration of pond liquids or sediments into, or possibly through, the lining will be evaluated for sampling. The most damaged locations will be selected for sampling, with a maximum of six sample locations per pond. Six samples are expected to be an adequate quantity to characterize conditions which may be expected at damaged liner locations. These samples will be obtained so that a portion of the crack or other damage of interest is included in the sample. Liner and base course samples will also be obtained at 28 selected locations described in Subsection 4.5.2.

Sampling the pond liners and base course material can begin after the surface contaminant survey is completed. However, sampling should be initiated not more than 1 week following the surface contaminant survey. The arbitrary limit of 1 week is to ensure that the results of the surface contaminant survey are relevant to the fieldwork. Liquids (except for natural precipitation) should not be introduced into the ponds after the surface contaminant survey has been completed.

Liner samples will be excavated with either an air-driven or electric-powered jackhammer. The jackhammer will break up the asphaltic lining components into small pieces, which can be easily placed into sample containers. The use of a jackhammer will not require introduction of water as is required with typical asphalt or concrete coring equipment. A sufficient amount of asphalt will be excavated to meet laboratory sample requirements and also to allow further excavation of the underlying base course materials. Base course materials may be excavated using a long handled spoon, trowel, small shovel, or other similar tool. Separate sample containers will be provided for base course samples. All sampling tools will be decontaminated before each sampling event to minimize the potential for cross-contamination. Sample containers will be selected with consideration of the potentially awkward-sized liner and base course material particles resulting from the excavation. All liner and base course sampling will be performed in accordance with EG&G SOPs. Details on decontamination procedures, sample handling procedures, analysis, screening, and sample designation are provided in Subsection 4.6.

If an air-driven jackhammer is used, a portable power source with a gasoline or diesel engine may be needed. If an electric-powered jackhammer is used, a power source may be available in the nearby buildings; otherwise, a portable generator will be required. All engine-driven power sources will be located outside the pond perimeter and downwind such that when operating, the power source is never closer than 100 feet to the sampling location. This will minimize the possibility of introducing further contaminants from the engine exhaust.

Vadose zone sampling. Boreholes will be installed at 28 locations (see Figure 4-5) using hollow-stem auger drilling equipment, procedures (for drilling, soil and rock sampling, and water sampling), and sampling intervals as described in Subsection 4.4.3. A skid- or trailer-mounted drilling rig may be required because of the limited access down the side slopes of the ponds. Drilling depths are expected to vary from approximately 15 to 25 feet for the 28 boreholes within the boundaries of the Solar Evaporation Ponds. Criteria for target drilling depths is the same as provided in Subsection 4.4.3. However, the target depths and criteria may be revised or refined based on the results of the sampling (vadose zone drilling outside of the boundaries of the Solar Evaporation Ponds) performed in Task 4, previously described.

4.6 SAMPLE ANALYSIS AND HANDLING

The analytes and sample handling procedures and protocol are provided in this subsection.

4.6.1 SAMPLE ANALYSIS

Provided in Table 4-3 is the list of chemical and radiological analytes for pond liquid and sediment samples; liner and base course samples; soil/vadose zone samples; and water samples taken during drilling. Analysis of pond liquids and water collected during vadose zone drilling will be performed on both filtered and unfiltered samples for radionuclides and metals. Analysis of volatile organics, semi-volatile organics, and inorganics will only be performed on the unfiltered sample. The liquid will be filtered with a 0.45 micron filter in accordance with EG&G SOPs. EPA Contract Laboratory Program (CLP) laboratory protocol, or protocol as determined by EG&G, will be used for all chemical and radiological analysis.

Geotechnical tests will be performed on selected vadose zone samples (see Subsection 4.4). Samples of soil and rock selected for geotechnical testing will be analyzed in accordance with American Society of Testing and Materials (ASTM) procedures for the properties presented in Table 4-4, as directed by site personnel. The geotechnical testing will enable the classification of alluvial samples in accordance with the Unified Soil Classification System (USCS), and will aid in lithologic identification and correlation to other borings.

4.6.2 FIELD SCREENING OF SAMPLES

All samples (pond liquids and sediments, soil and rock core, borehole water, and auger cuttings) obtained during the investigation will be screened with hand-held field instruments for alpha, beta, and gamma radiation, and VOCs. A laboratory-quality alpha detector and sodium-iodine, beta/gamma detector that reads in counts per minute will be used. Radiation survey equipment, use and procedures for field screening will be in accordance with EG&G SOPs. At minimum, a photo-ionization detector will be used to detect VOCs evolving from samples. Equipment, use, and procedures for field screening of VOCs will be in accordance with EG&G SOPs.

4.6.3 SAMPLE CONTAINERS, PRESERVATION, AND SHIPPING

All sample container size, material, preservation, and precleaning requirements will be in accordance with the Rocky Flats ER Program SOPs and QA/QC Plan (EG&G, 1990b, in preparation) for the type of sample and analysis to be performed. Offsite shipping of samples shall be in accordance with EG&G SOPs (EG&G, 1990c, in preparation) and applicable DOT regulations.

4.6.4 SAMPLE IDENTIFICATION SYSTEM

Each sample collected for analysis, including duplicates, field blanks, and trip blanks will be coded with an unique sample identification. The sample identification code will include information regarding the boring number, sample depth, and type. Sample depth will be measured to the nearest tenth of a foot. Sample type will be designated with a code for the sampling instrument, with typical codes as follow:

CCS = Continuous-cored split-spoon
SS = Split-spoon drive sample
CT = Drill cuttings sample
PQ = Pond liquid sample

PS = Pond sediment sample

PL = Pond liner or base course sample

An example of a soil sample identification code for a continuous-cored split-spoon sample taken at a depth of 10 feet in boring number SEP-01-SB90 would be: SEP-01-SB90/10/CCS. If different borehole and sample identification codes are developed by EG&G before mobilizing the sampling effort, that system would be used.

4.6.5 FIELD QUALITY ASSURANCE/QUALITY CONTROL

The field quality assurance/quality control program will follow procedures to be outlined in the Rocky Flats ER Program Quality Assurance/Quality Control Plan (EG&G, 1990b, in preparation). It includes two basic areas: documentation of field activities (i.e., decontamination procedures, sampling techniques, unusual occurrences, preservation of samples and order in which samples were collected), and the routine collection and analysis of trip blanks and field (equipment) blanks. In addition:

- For all samples, the sample extraction implement will be dedicated to the sample, disposed of, or thoroughly decontaminated prior to use on another sample.

- All sampling personnel will be required to avoid actions potentially causing cross contamination of sampling media (e.g., dispose of boot covers or decontaminate boots between sampling locations).

- Sample extraction equipment will not be placed upon the ground or other potentially contaminated surfaces before use.

- Onsite sample management will be meticulous in order to preserve the quality of the data.

4.6.6 FIELD DECONTAMINATION

To reduce the potential for cross contamination occurring, the floating work platform, hollow stem augers, drill rods, and all other pertinent sampling equipment will be decontaminated in accordance with applicable SOPs (EG&G, 1990c, in preparation). All other sampling equipment will be decontaminated between sample locations unless they are disposable. One exception is the floating work platform which will be decontaminated between ponds only. All sampling equipment shall be decontaminated before first use and before leaving the site except for precleaned sample containers.

4.7 HEALTH AND SAFETY PLAN

A site-specific health and safety plan will be written in accordance with the ER Health and Safety Program Plan (EG&G, 1990d, in preparation).

All field personnel will thoroughly review the site-specific health and safety plan, understand the safety considerations and establish emergency procedures prior to site entry. All personnel must be subject to an active medical surveillance program and be authorized for use of respiratory protection.

Section 5

Section 5

5.0 DATA EVALUATION AND REPORT

5.1 INTRODUCTION

A data evaluation and report will follow the field investigations described in previous sections of this document. The data collected during these investigations will introduce new information on conditions in the vicinity of the Solar Evaporation Ponds unit. This data will help to confirm previously collected information and confirm and refine the conceptual model.

Information collected in the Phase I RFI/RI will include field descriptions of vadose zone material, and analytical results from selected surficial soil, vadose zone, pond liner pond base course, and French drain liquid samples. This information will include geological and analytical data from soil/vadose zone borings directly beneath the Solar Evaporation Ponds. This information may help clarify the amount and composition of contaminants that have leaked through the Pond lining. This new information will also help define the composition and nature of the geologic units beneath the ponds, which in turn, will be valuable in addressing the issues of contaminant migration and transport of contaminants from the Solar Evaporation Pond area.

The information collected in the vicinity of the Ponds will be available for comparison to previously collected data. A comparison of geological data will help refine the geologic model in the vicinity of the Ponds. This comparison, in turn, will help refine the conceptual model of contaminant migration pathways and transport. A comparison of analytical data may be useful in identifying areal and temporal trends in contaminants in the vicinity of the Ponds.

5.2 DATA EVALUATION

Data evaluation will occur in two distinct tasks. In one sense, data will be evaluated in terms of its usability or quality. This validation process is conducted as the data are generated and should be completed before further evaluation occurs. A description of the data validation plan for the Solar Evaporation Ponds investigations is included in the Quality Assurance Project Plan (QAPP) (EG&G, 1990a). The second form is the technical evaluation, at which point the information that is required to make decisions to successfully complete the RFI/RI process, will be extracted from the data.

The objectives of the data evaluation task are to achieve the following:

- Confirm that the data are representative of the media sampled and that the quality assurance/quality control (QA/QC) criteria have been met. This process is known as data validation and will be conducted prior to technical evaluation of the data.

- Compile and present the data in forms most appropriate to the end uses of the data.

To address the first objective, all laboratory data generated during the RFI/RI will be validated in accordance with the QAPP and QA/QC Plans (EG&G, 1990a, and 1990b). Data validation is a quantitative and qualitative review of specified QA/QC parameters: laboratory precision and accuracy, method blanks, field blanks, instrument calibration, and holding times. This review will assess the usability (quality) of the data for subsequent RI data reduction, evaluation of remedial alternatives and risk assessment. Data validation will be conducted throughout the RI as data are generated.

The usability of analytical (chemical and radiological) and geologic data will be assessed in a qualitative sense via the technical review process. To help assure that the data are of acceptable quality, the field personnel responsible for data collection will be trained and qualified. The geologic logs will be reviewed daily by the project geologist for quality and consistency. Senior technical reviews will be conducted periodically throughout the project.

To address the second objective, the data collected as part of this investigation, in addition to existing available data (of various levels of quality) will be evaluated for correlations between similar and dissimilar data types (statistical methods will be used as appropriate) and for trends, both temporal and in space. Geochemical properties of the vadose zone, especially as they relate to contaminant transport and remediation, will be evaluated. Iso-concentration maps of selected vadose zone parameters and/or combinations of parameters will be prepared. These maps will be compared to iso-concentration maps for the groundwater in the unconfined groundwater system. They will also be useful in estimating the distribution of contaminants in the vadose zone and for further screening of remedial actions.

5.3 PHASE I RFI/RI REPORT

A report will be prepared summarizing the data and evaluations from the Phase I RFI/RI. Information pertinent to the conceptual model will be refined; sources of contaminant releases will be more definitively identified; the nature and extent of contamination within the pond liquid and sediments, lining, and soil/vadose zone will be described and the risks associated with the contaminant releases will be presented.

The report resulting from the Solar Evaporation Ponds RFI/RI Work Plan activities will be prepared according to the following format:

1.0 INTRODUCTION

1.1 <u>PURPOSE AND OBJECTIVES</u>

1.1.1 Regulatory Background

1.1.2 Technical Objective

1.2 <u>SCOPE OF REPORT</u>

1.2.1 Solar Evaporation Pond Description and Characterization

1.2.2 Baseline Risk Assessment and Environmental Evaluation

2.0 SITE BACKGROUND AND DESCRIPTION

2.1 <u>DESCRIPTION OF SOLAR EVAPORATION PONDS</u>

2.1.1 Location

2.1.2 History

2.1.3 Unit Characteristics

2.1.4 Waste Characteristics

2.2 <u>SITE CONDITIONS</u>

2.2.1 Topography

2.2.2 Surface Water

2.2.3 Geology

2.2.4 Soils/Vadose Zone

2.2.5 Groundwater

2.3 <u>SUMMARY OF PREVIOUS UNIT INVESTIGATIONS</u>

Section 6

Section 6

6.0 PHASE I RFI/RI SCHEDULE

The anticipated schedule for completing the RFI/RI is presented in Figure 6-1. The following key assumptions were used in the development of this schedule.

- The schedule is for Phase I RFI/RI investigations only. Subsequent phases of these investigations or additional activities, if required, may lengthen the time required for closure of the Solar Evaporation Ponds.

- Activities preliminary to actual field sampling, such as area walkovers and clearing utility locations, will be conducted at one time for the RI field investigations except for Task 5.

- Drilling subcontractor procurement requires 60 calendar days.

- Preliminary surface monitoring surveys of the work area, and monitoring during sampling, will indicate established Health and Safety requirements are being met.

- All TCL, TAL, nonradioactive Special Analytical Services (SAS), and radionuclide analyses will require a 90 calendar-day turnaround time. This timeframe includes 30 calendar days for laboratory QA/QC data validation.

TASK I EXISTING DATA COMPILATION

- A security escort will be readily available.
- Assume data compilation will require the labor of two and one-half full-time equivalents for a period of 1 month.
- Data are readily available and unclassified.

TASK II SOLAR EVAPORATION PONDS LIQUID AND SEDIMENT INVESTIGATIONS

- Work days within the PSZ are restricted to the hours of 8:30 a.m. to 3:30 p.m. Monday through Friday.
- A security escort will be readily available.
- All of the ponds contain some liquid and sediment, except Pond 207-A, which is assumed to not contain sediment.
- A pond liquid/sediment sampling staging area can be established adjacent to the ponds in the PSZ.
- A suitable pontoon boat is readily available from DOE and/or EG&G, and is fully operational.
- The pontoon boat and associated pond liquid and sediment sampling equipment can be decontaminated in the PSZ, and decontamination

water can be placed in the pond from which the pontoon boat/ equipment was last used.

TASK III FRENCH DRAIN SYSTEM LIQUID INVESTIGATIONS

- Work days within the PSZ are restricted to the hours of 8:30 a.m. to 3:30 p.m. Monday through Friday.
- A security escort will be readily available.
- Manholes are readily accessed.
- Suitable decontamination facilities are readily available.

TASK IV SOIL/VADOSE ZONE INVESTIGATION

- Work days within the PSZ are restricted to the hours of 8:30 a.m. to 3:30 p.m. daily, with drilling rates averaging 20 feet per day.
- A security escort will be readily available.
- Suitable decontamination facilities are readily available.
- Core samples will be logged and packaged for storage by EG&G.

- One drilling rig (3.25-inch I.D. hollow-stem auger air rotary) will be used for the soil borings.

- Each soil boring will be backfilled with bentonite slurry.

- Drill cutting, waste protective gear and clothing, and water derived from drilling will be drummed for disposal by EG&G.

- Drilling will be performed under personal protection level "D."

TASK V SOLAR EVAPORATION POND LINER, BASE COURSE, AND VADOSE ZONE INVESTIGATIONS

- Work days within the PSZ are restricted to the hours of 8:30 a.m. to 3:30 p.m. Monday through Friday, with drilling rates averaging 20 feet per day.

- A security escort will be readily available.

- Suitable decontamination facilities are readily available.

- Core samples will be logged and packaged for storage by EG&G.

- One drilling rig (3.25-inch hollow-stem auger air rotary) will be used for the soil borings.

- Each soil boring will be backfilled with bentonite slurry.

- Drill cutting, waste protective gear and clothing, and water derived from drilling will be drummed for disposal by EG&G.

- Liquid and sediment is removed from all of the ponds prior to Pond Liner/Base Course Investigation.

- At a maximum, six additional liner/base course samples per pond will be collected from damaged portions of the Ponds.

- Sampling and drilling will be performed under personal protection level "D."

Section 7

Section 7

7.0 BIBLIOGRAPHY

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Appendix A

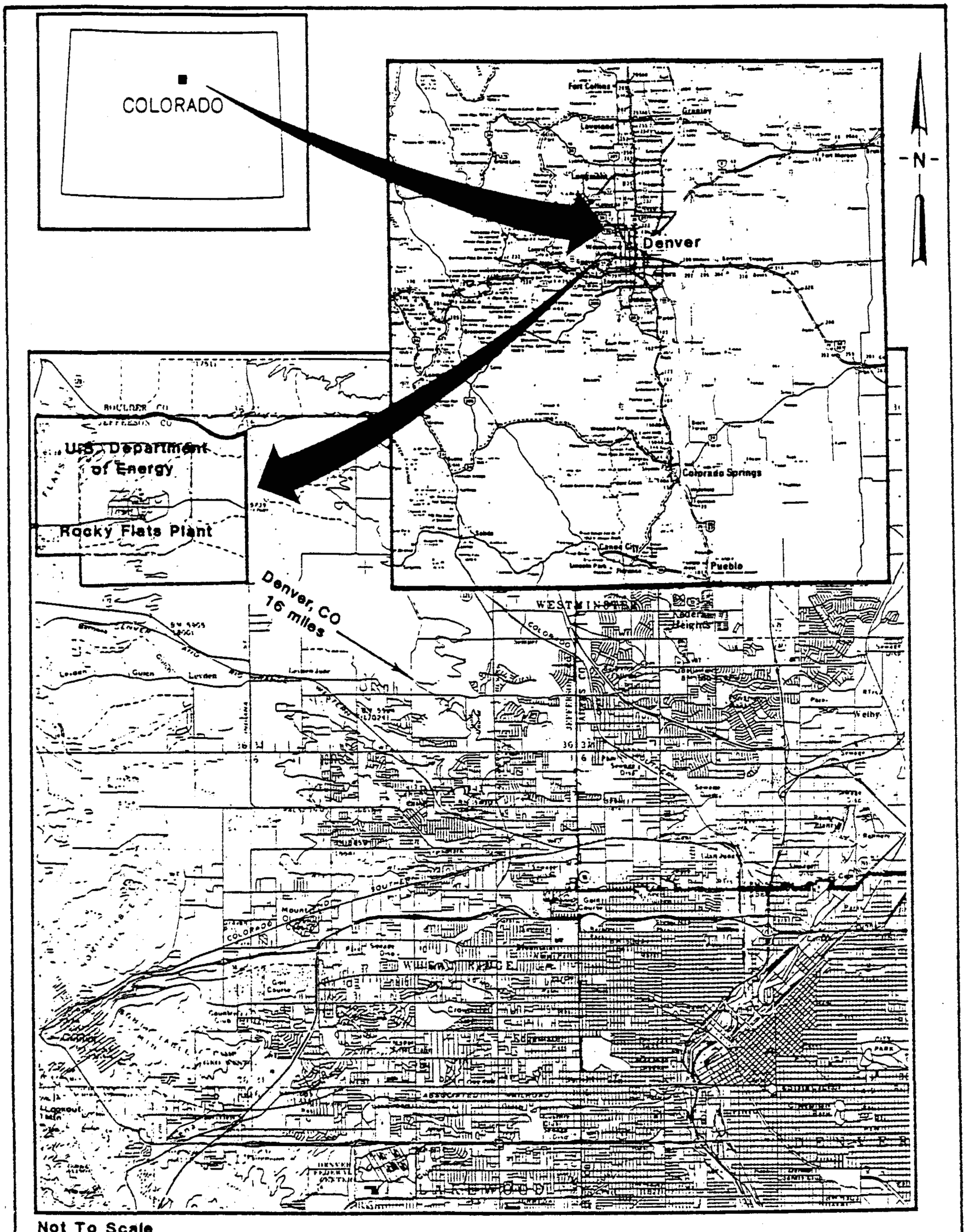


Figure 1-1: **Location of Rocky Flats Plant**

After: Rockwell, 1988b Vol. II P. 2-4

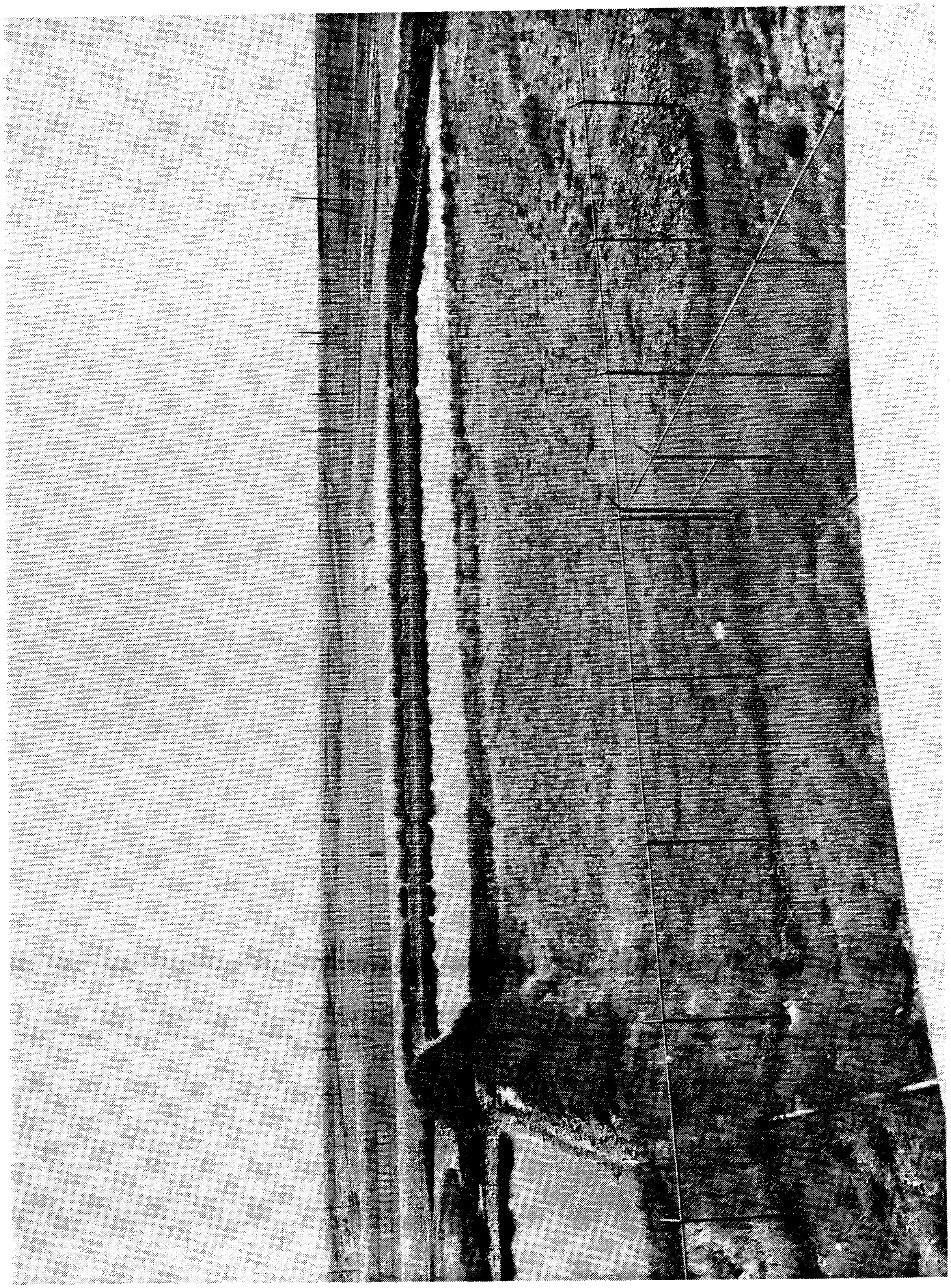


Figure 2-3
Easterly View of Original Solar Evaporation Ponds Taken from the West Side of the Original Solar Evaporation Ponds

After: Blaha, 1990

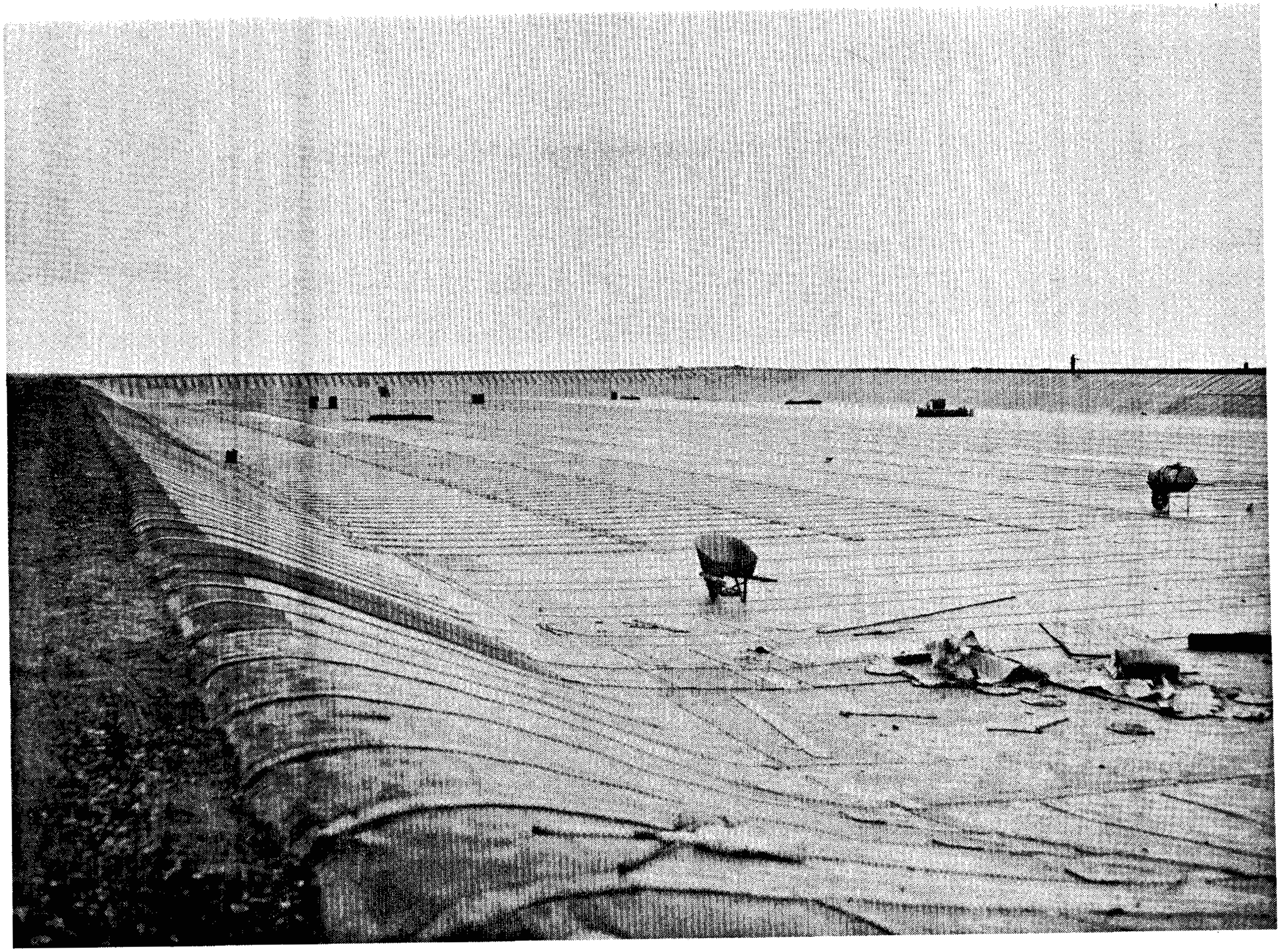
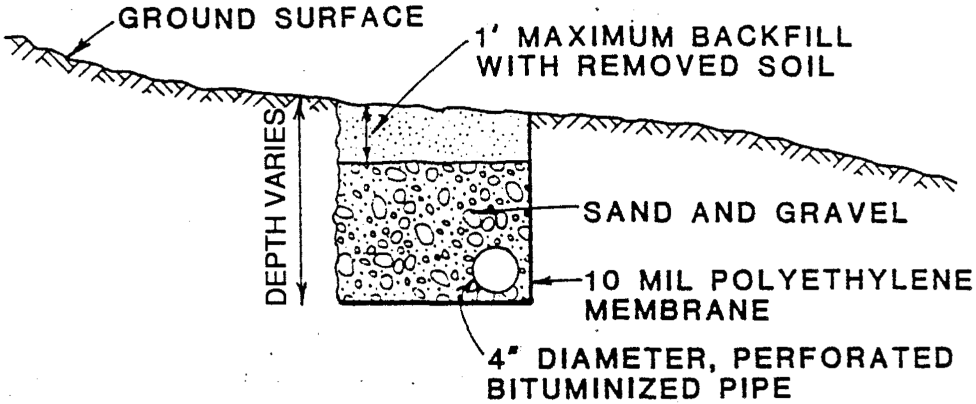
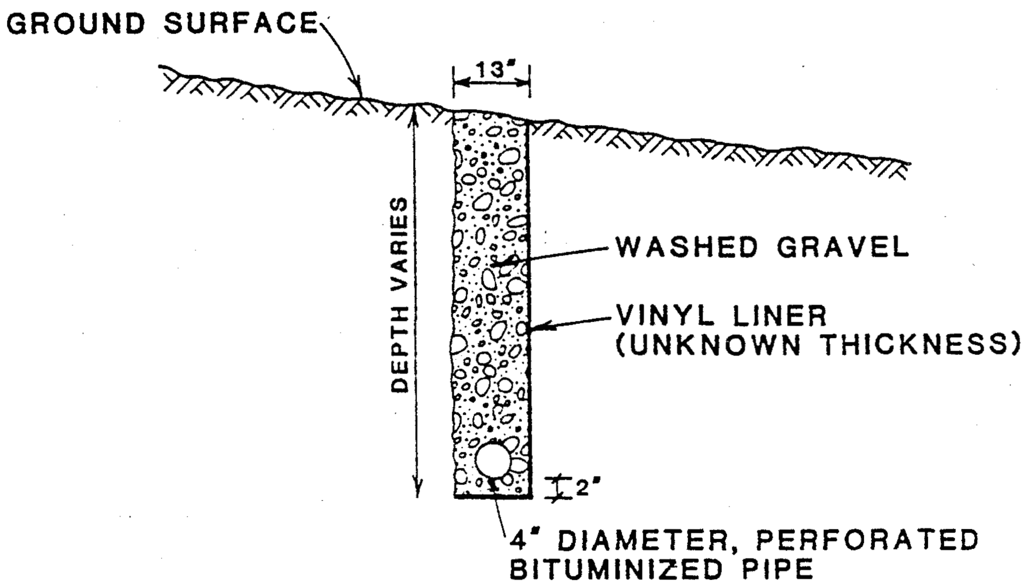


Figure 2-5
Pond 207-A Original Construction of Asphalt Planking

After: Blaha, 1990



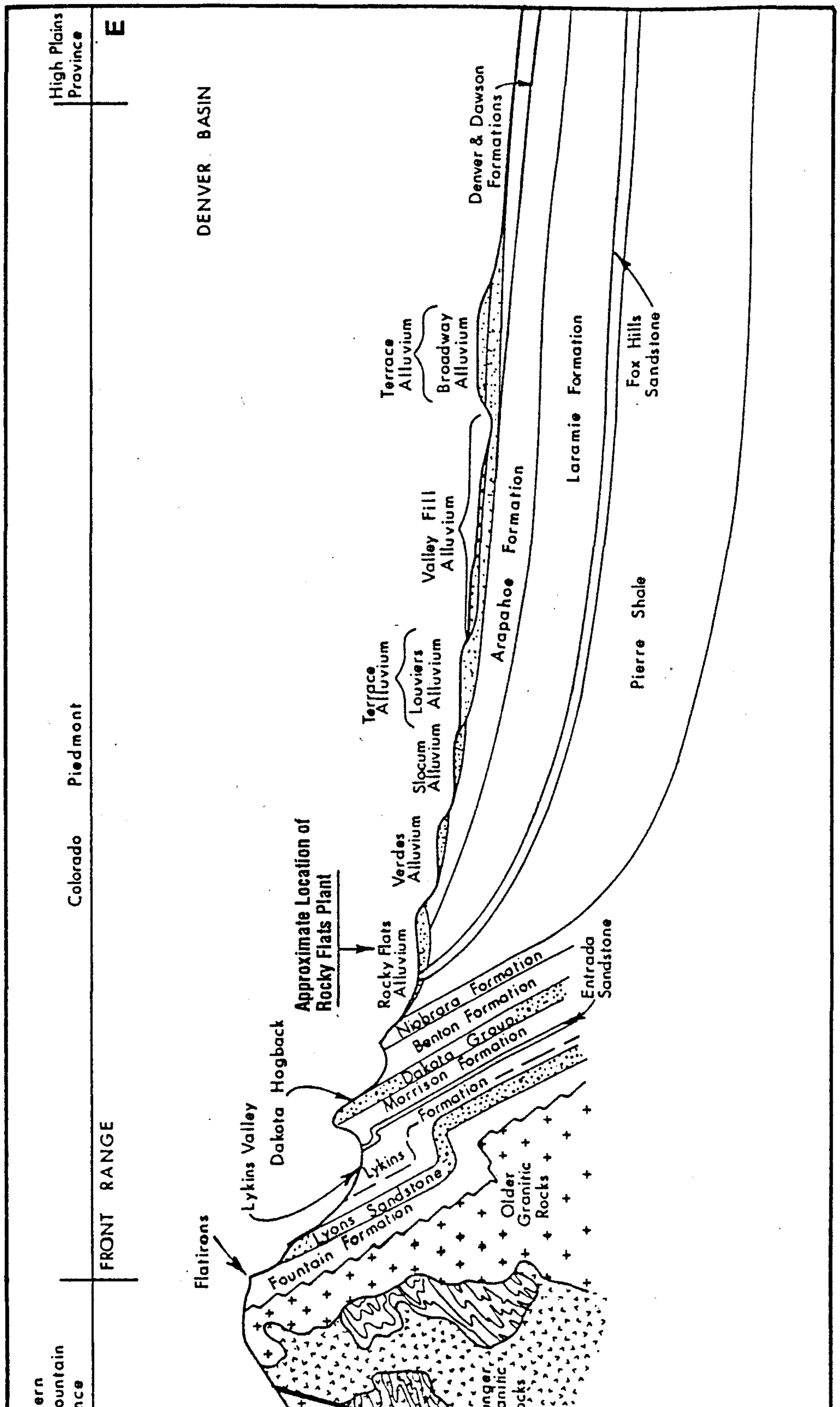
TYPICAL TRENCH AND REMAINING FRENCH DRAIN SYSTEM NOT ALONG SEGMENT D-D' CROSS-SECTION (NOT TO SCALE)



TYPICAL FRENCH DRAIN CROSS-SECTION ALONG SEGMENT D-D' OF FIGURE 2-2 (ROCKWELL, 1983a)

After: Rockwell, 1988b Vol. I P. 17

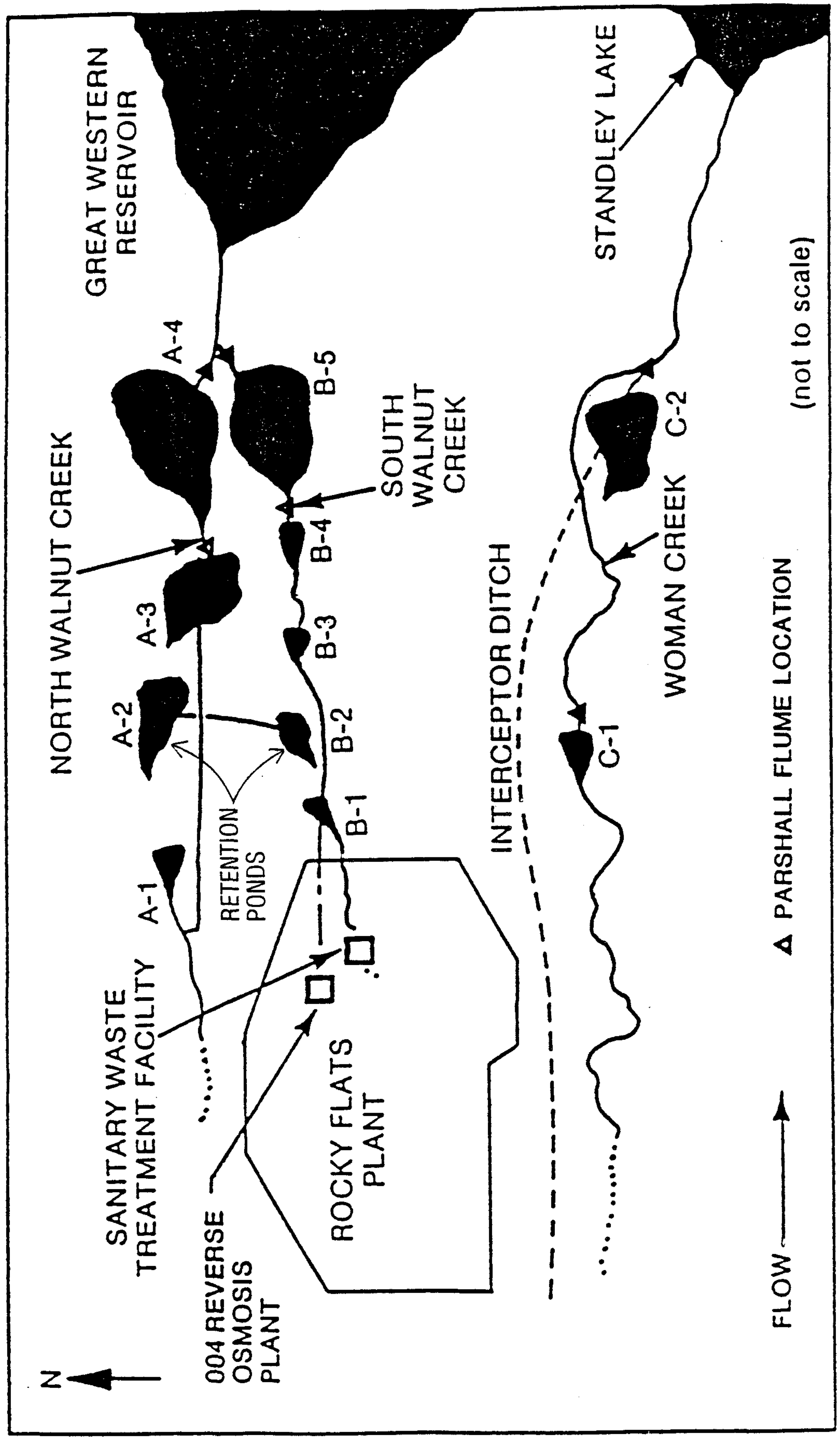
Figure 2-13
Typical Trench and French Drain Cross-Sections



Not To Scale

Figure 2-15
Generalized East-West Cross-Section
Front Range to Denver Basin

Modified After: Rockwell, 1988b Vol.II P. 3-4 (originally referenced from Boulder County Planning Commission, 1983 and Scott, 1960)



Modified After: Rockwell International, 1988

SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY1/027.51/d9

Figure 2-17
Retention Pond Locations

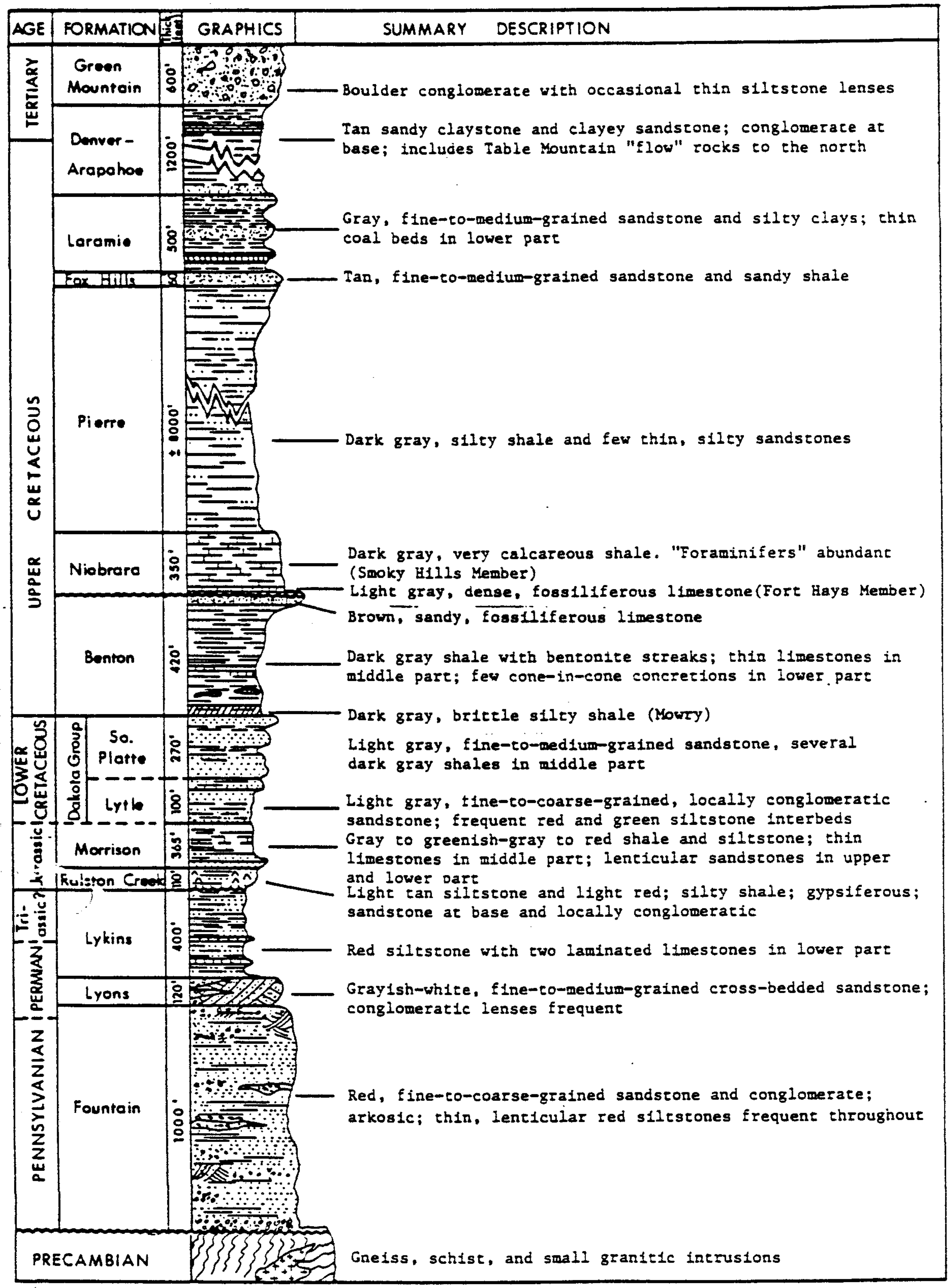


Figure 2-20: Generalized Stratigraphic Section, Golden Morrison Area

After: Rockwell International, 1988b Vol. II P. 3-9 originally referenced in Leroy & Weimer 1971

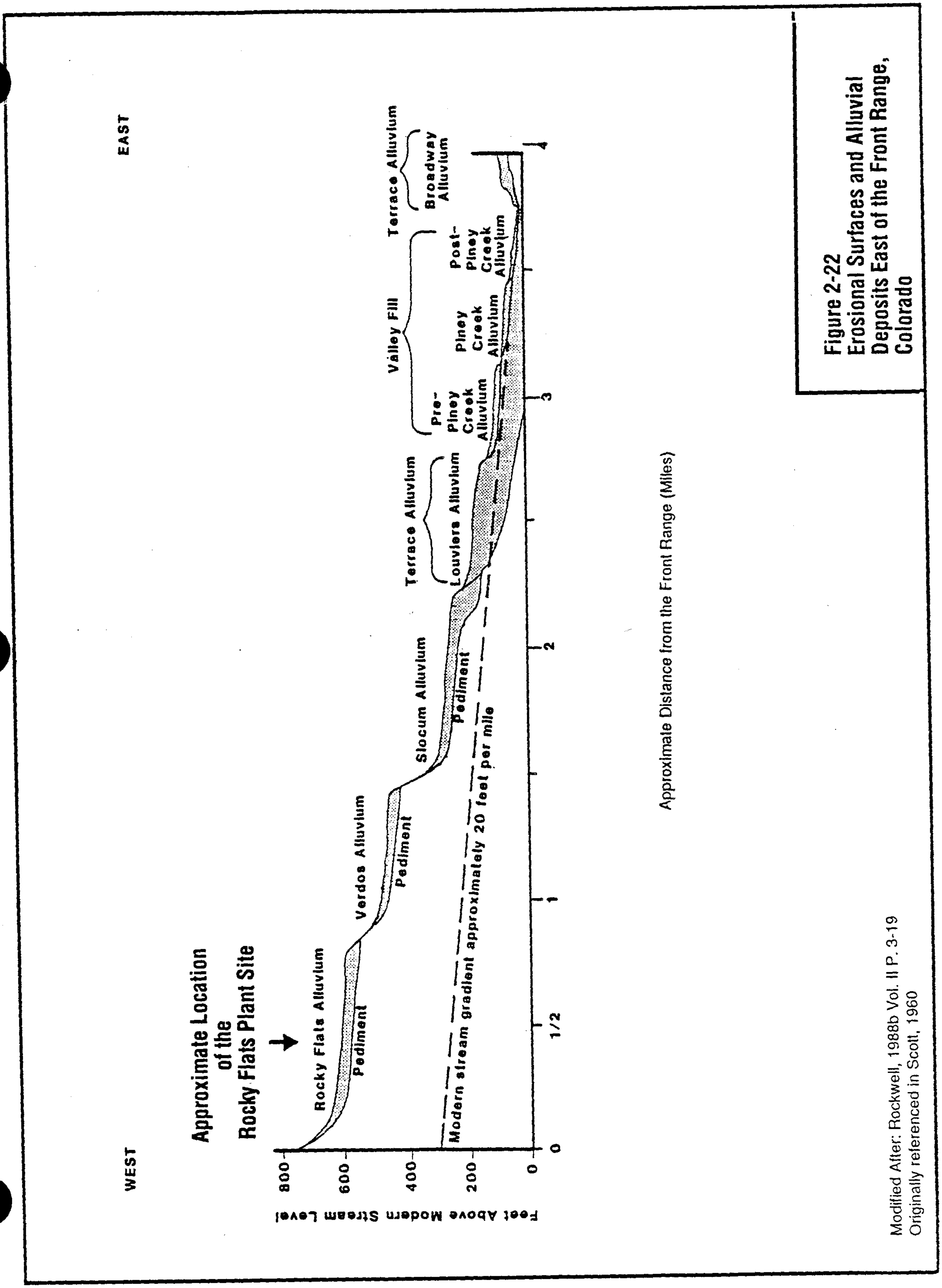


Figure 2-22
Erosional Surfaces and Alluvial Deposits East of the Front Range, Colorado

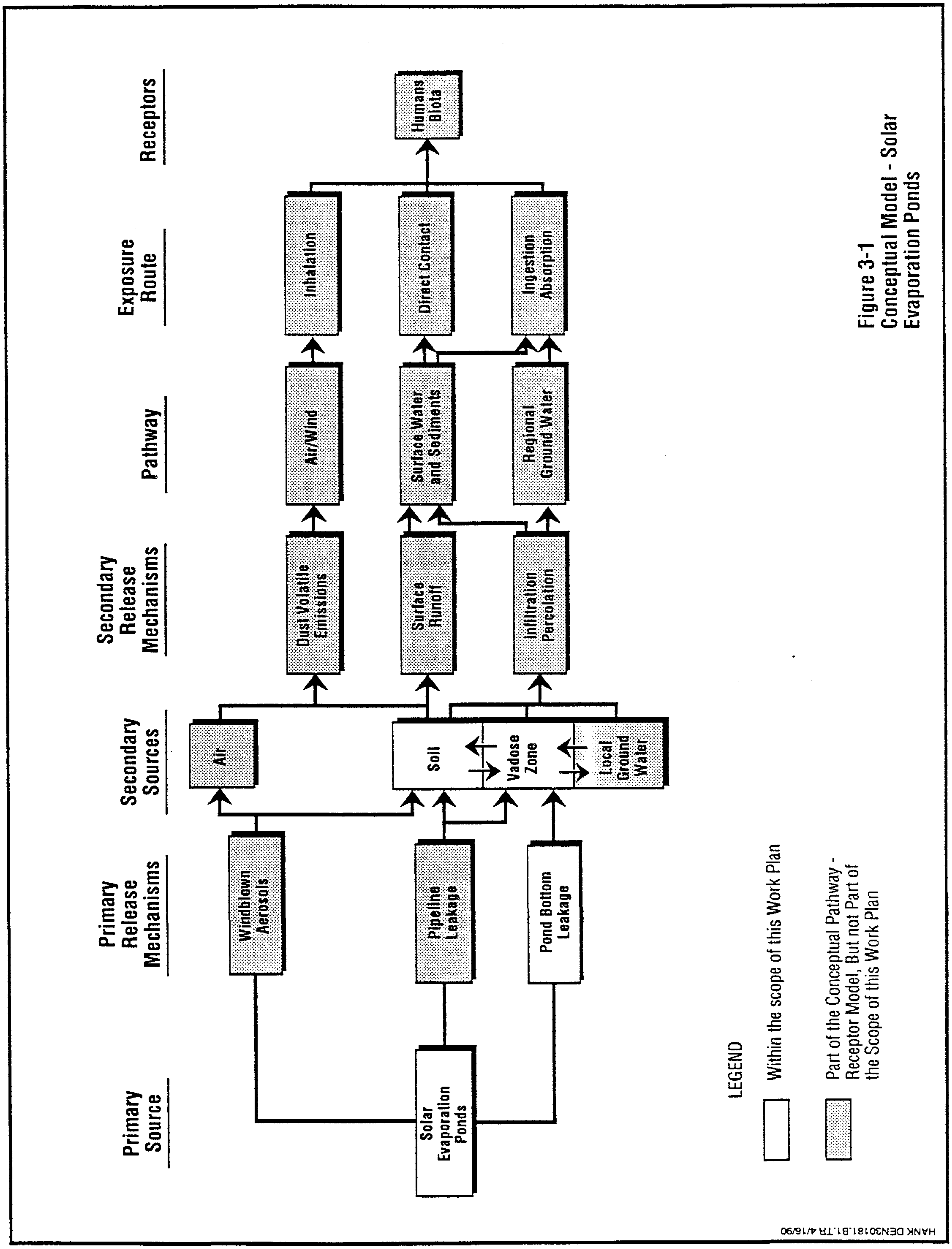


Figure 3-1
Conceptual Model - Solar Evaporation Ponds

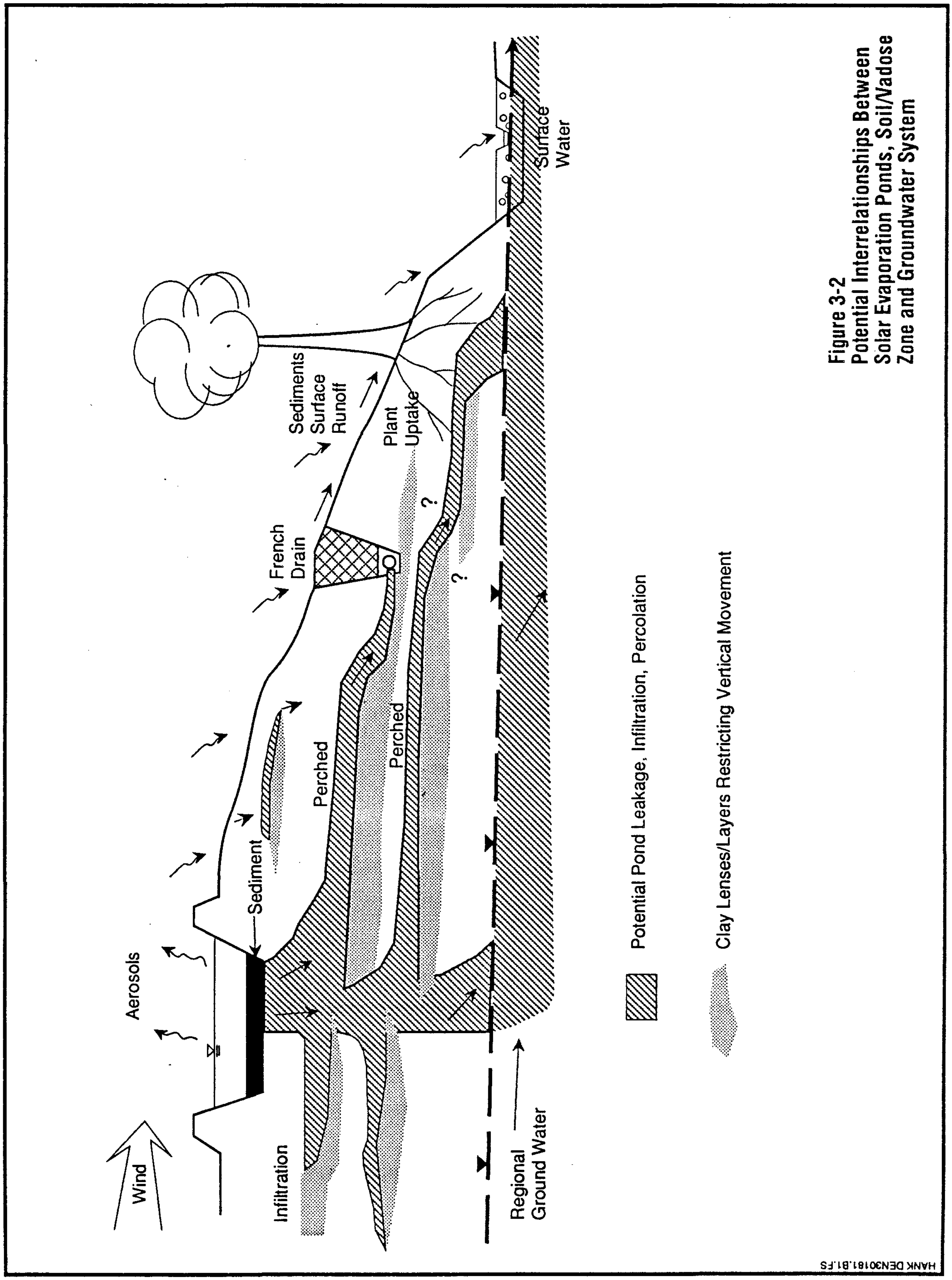
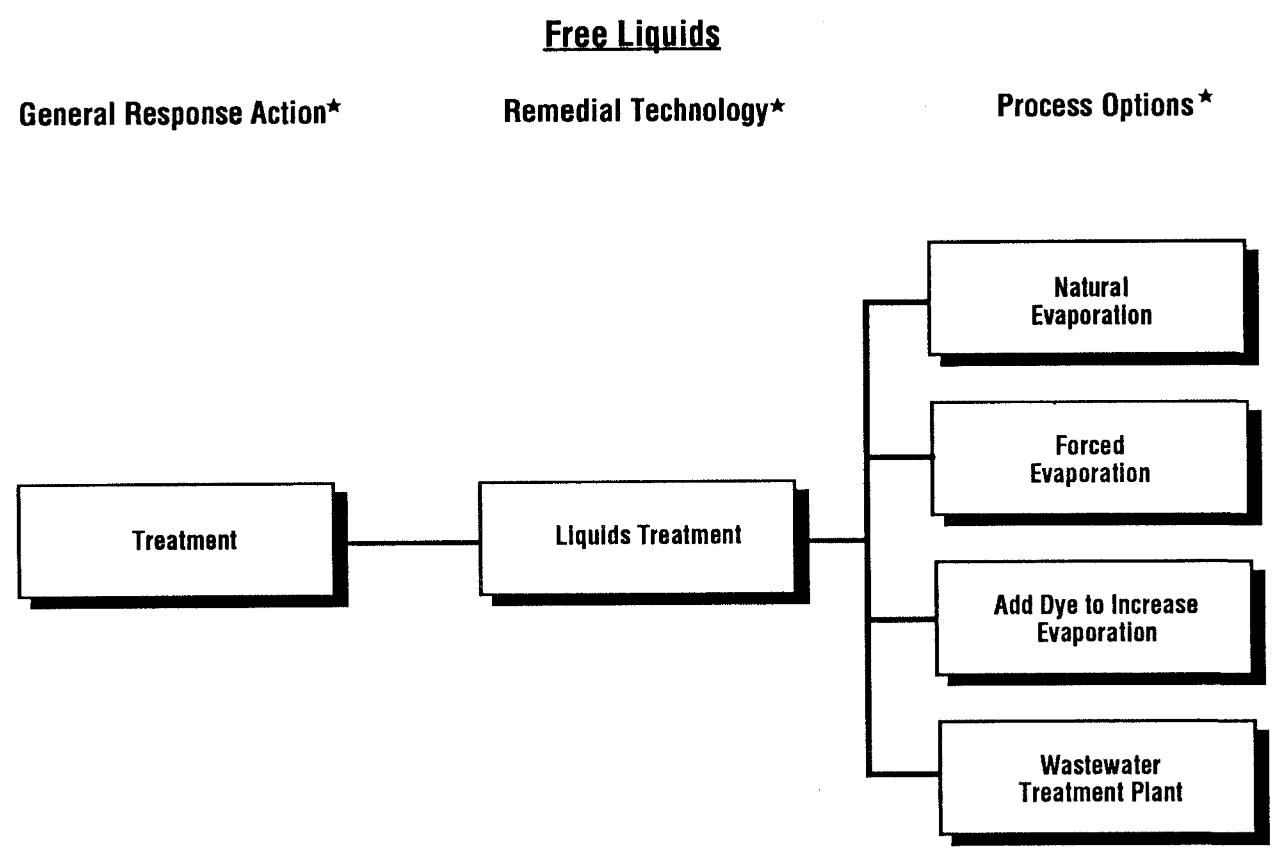
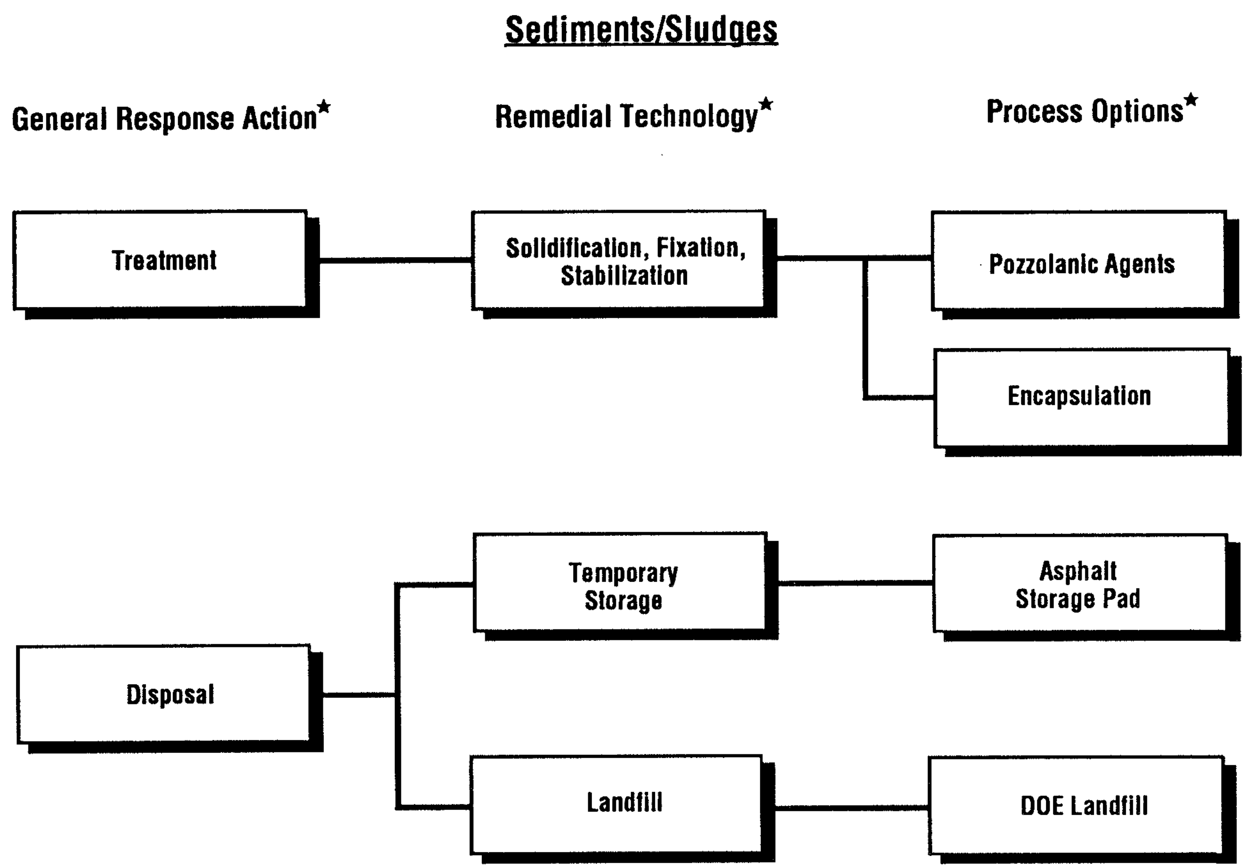


Figure 3-2
Potential Interrelationships Between Solar Evaporation Ponds, Soil/Vadose Zone and Groundwater System



*This figure illustrates the remedial actions currently being undertaken or planned.

Figure 3-3
Response Actions, Technologies, and Process Options - Free Liquids



*This figure illustrates the remedial actions currently being undertaken or planned.

Figure 3-4
Response Actions, Technologies, and Process Options - Sediments/Sludges

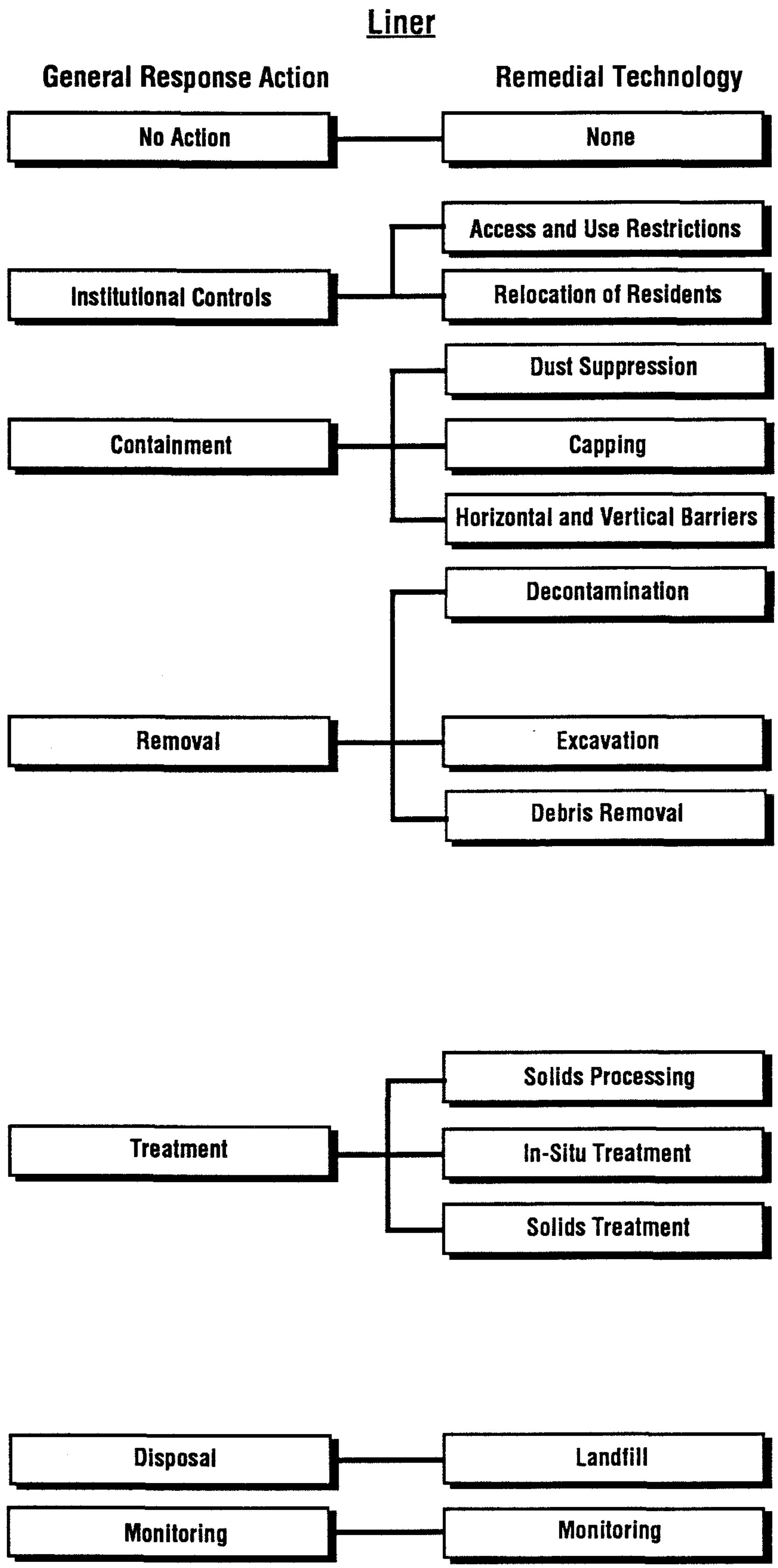


Figure 3-5
General Response Actions and Technologies - Liner

Embankment Soils, Underlying, and Surrounding Contaminated Soils

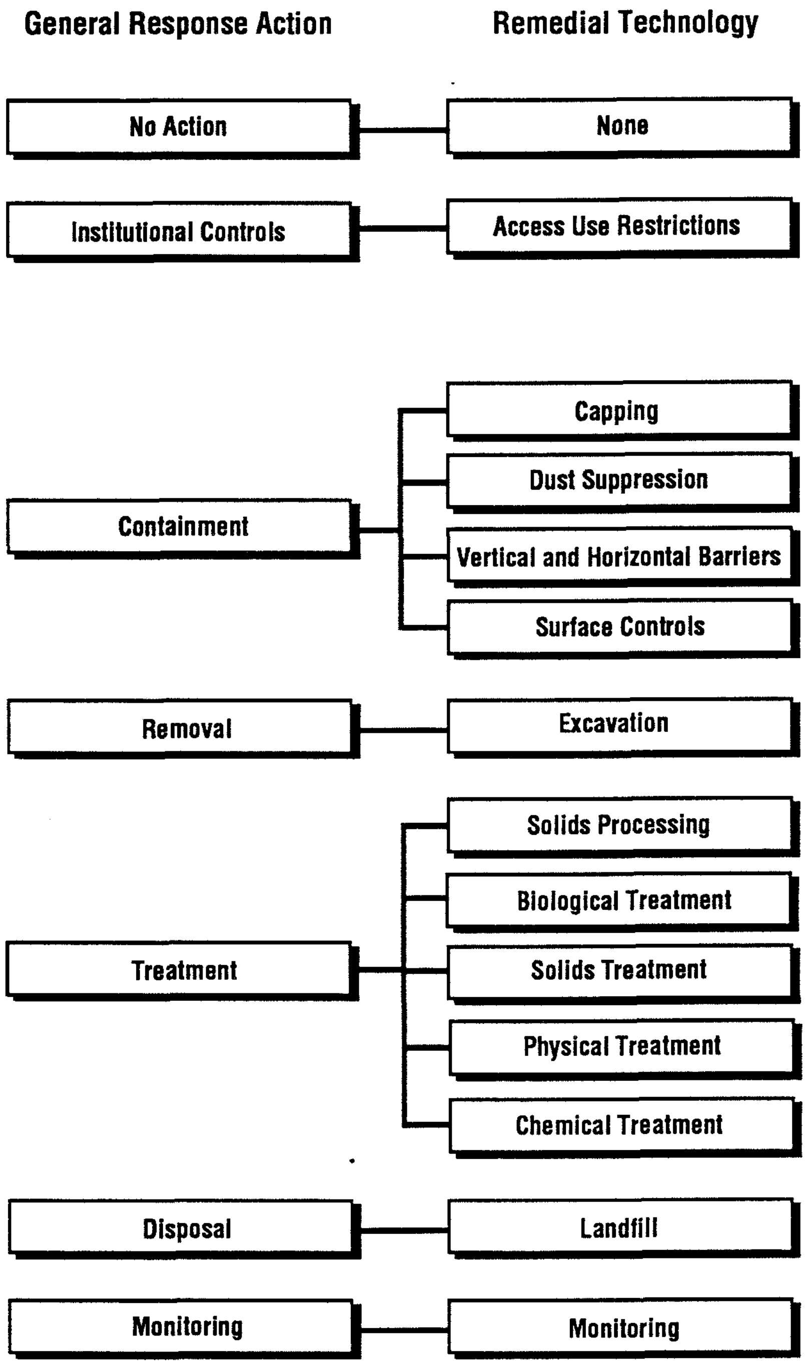


Figure 3-6
General Response Actions and Technologies - Soils

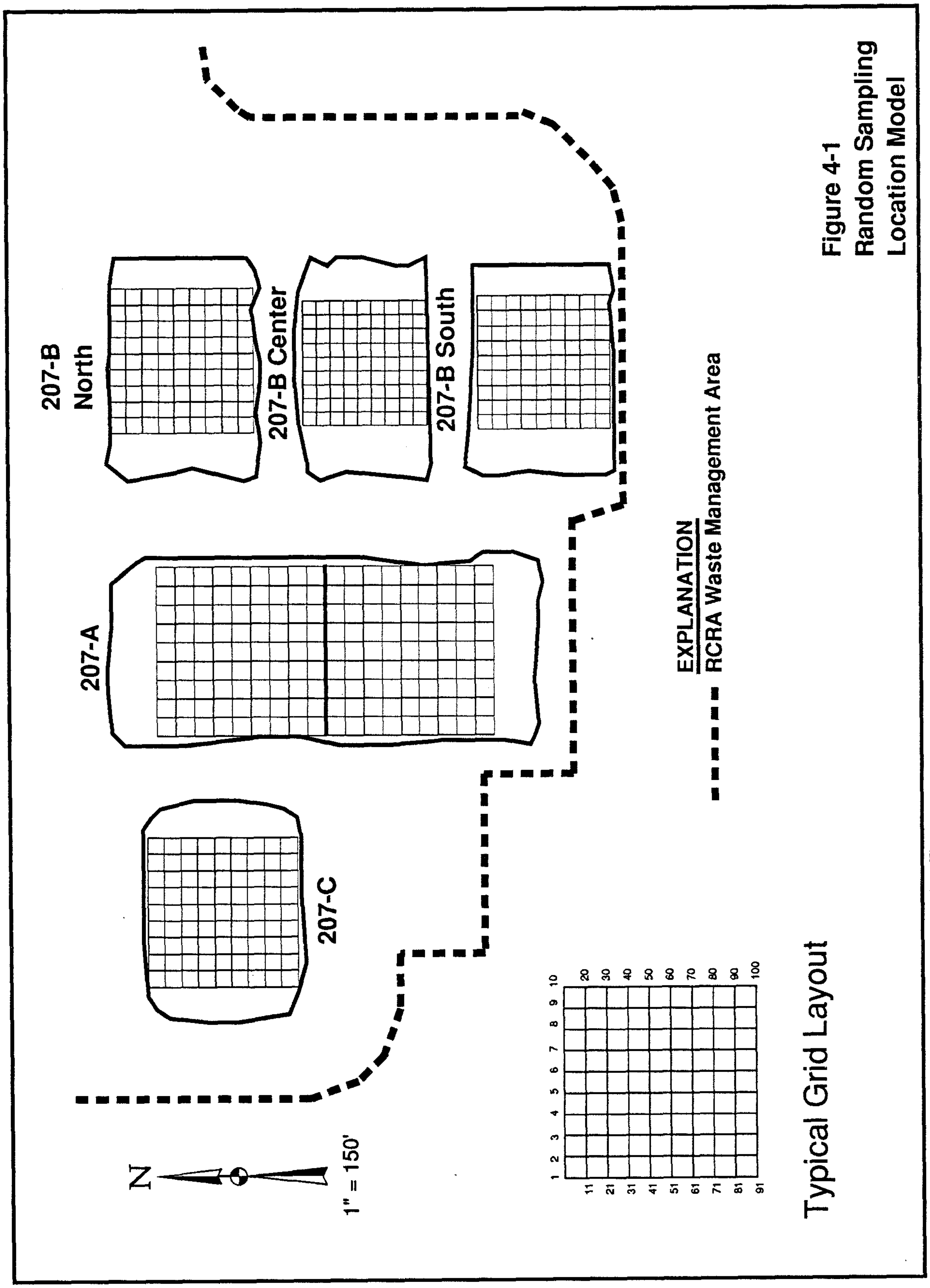


Figure 4-1
Random Sampling
Location Model

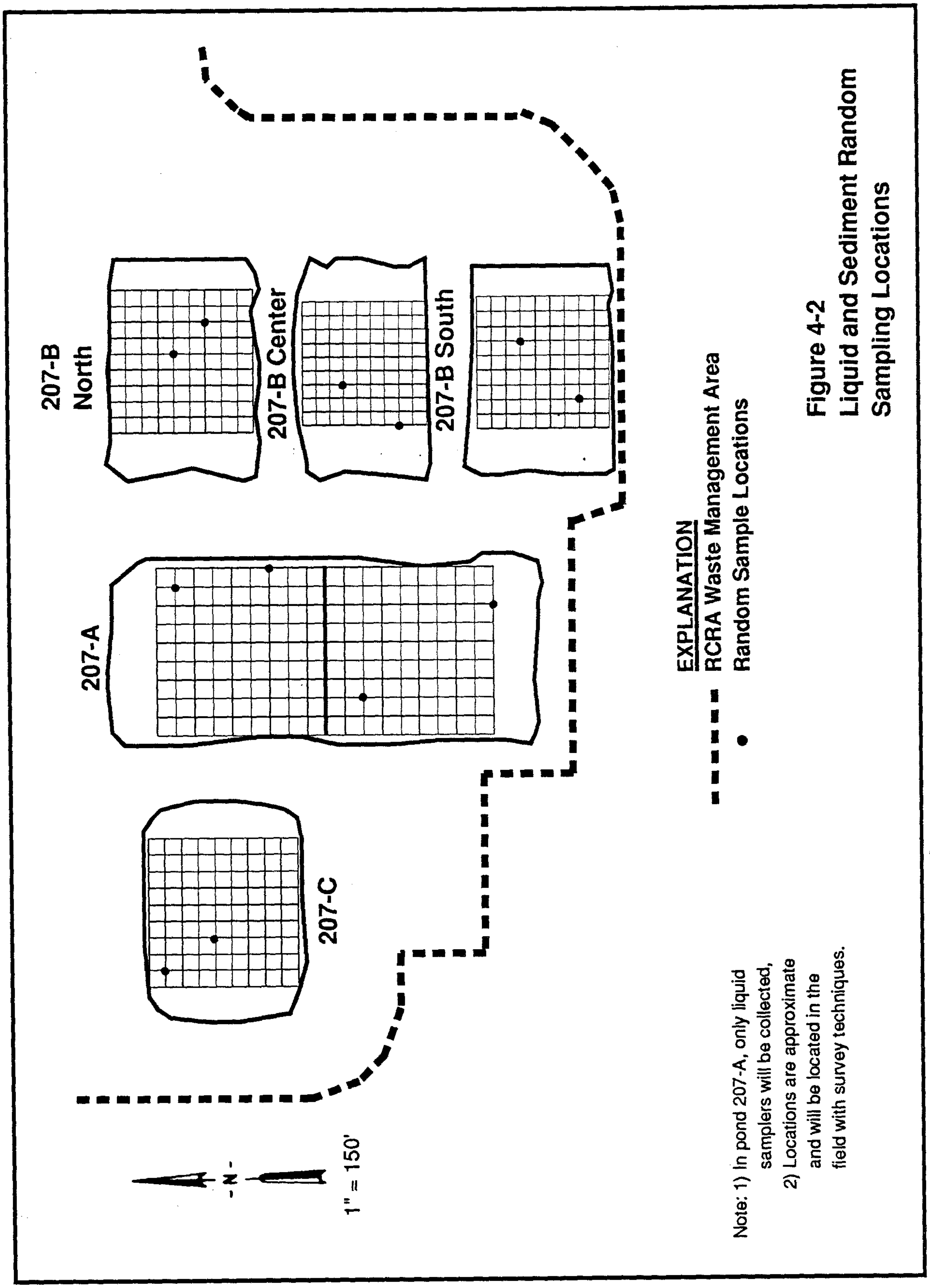


Figure 4-2
Liquid and Sediment Random Sampling Locations

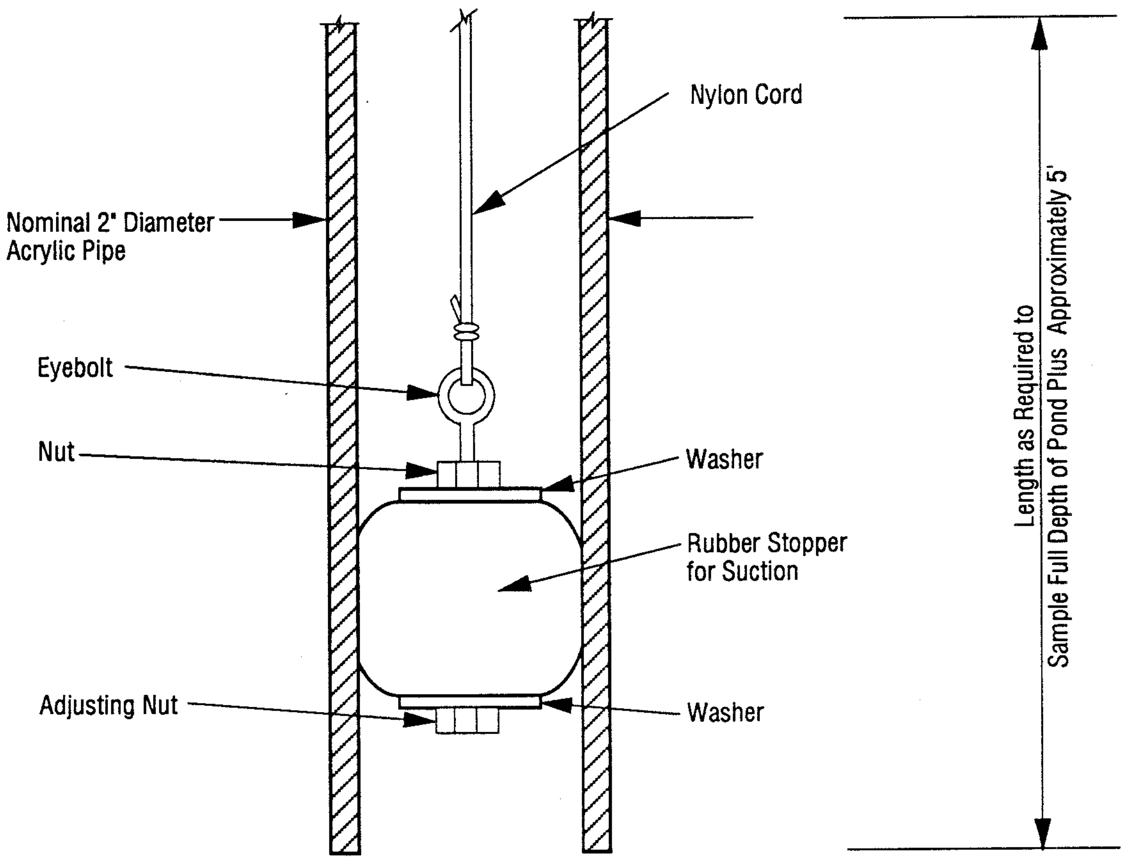


Figure 4-3
Pond Sediment Sampling Apparatus Schematic

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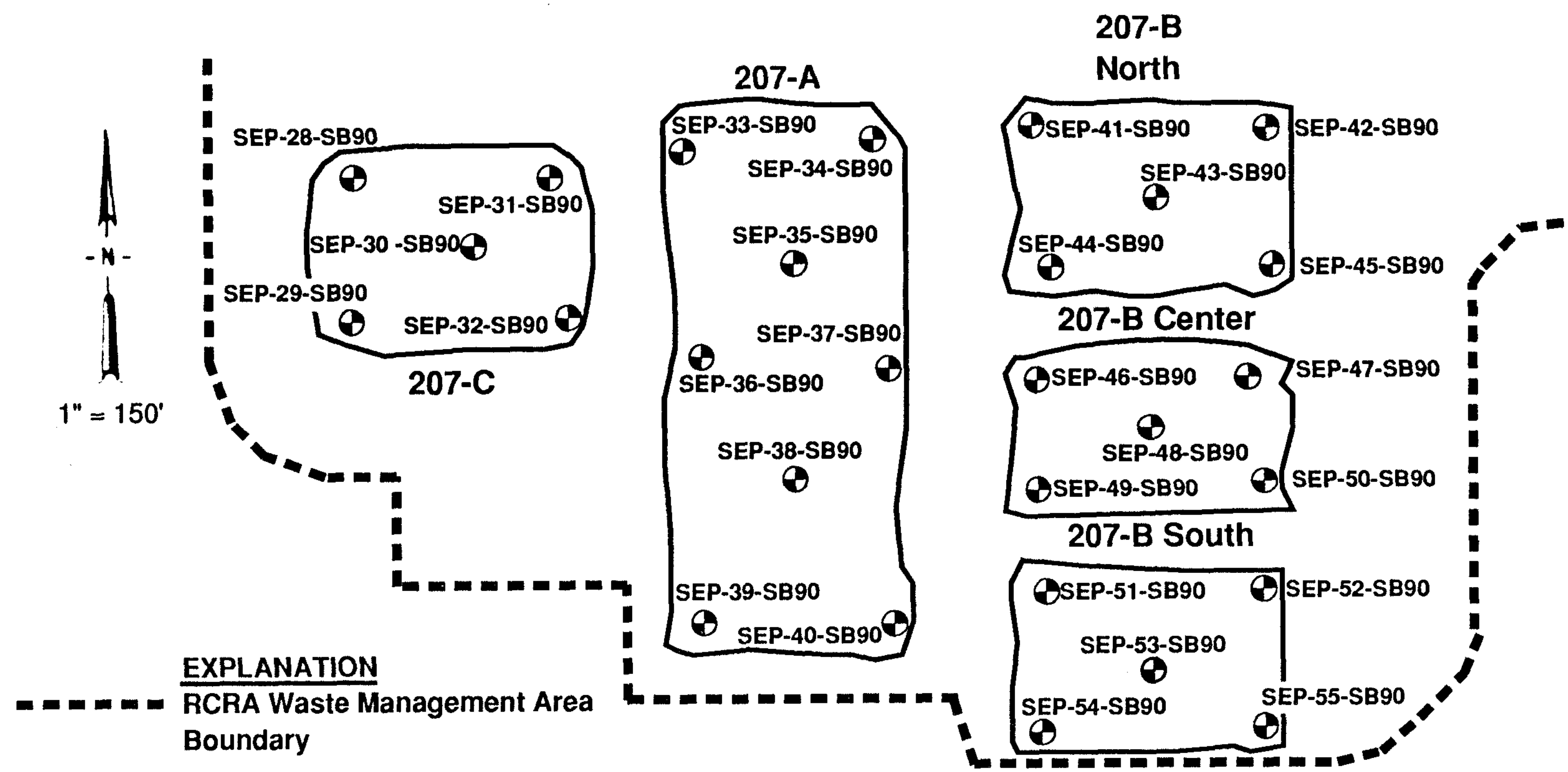
The Administrative Record Staff



EXPLANATION

RCRA Waste Management Area Boundary

SEP-28-SB90 — Proposed Soil/Vadose Zone Borehole Location

Note: 1) Locations are approximate. Final locations will be established in the field after overhead and underground facilities and structures have been located.

2) Borehole numbers SEP-01-SB90 through SEP-27-SB90 are shown on Figure 4-4.

Figure 4-5
Solar Evaporation Pond Liner, Base Course, and Vadose Zone Sampling Locations

Modified After: EG & G, March1, 1990, Vol. I, Fig 2-1

Appendix B

Table 2-1

SURFACE WATER SAMPLE INFORMATION
SOLAR POND SURFACE WATER SAMPLES

SAMPLE INFORMATION						LABORATORY BATCH NUMBERS					
Station Number	Number	Date	pH	Conduct (umho/cm)	Temp. (deg C)	Volatile Organics	Semi-Volatile Organics	Pesticides and PCB's	Metals	Inorganics	Radiochemistry
SW03	SW03088600	08/20/86	6.80	350	20.0	8608-044-021	8608-044-004	8608-044-004	8608-044-022	8608-044-023	1000-000-369
SW16	DRY	08/12/86									
SW17	SW17088600	08/12/86	6.00	700	17.0	8608-024-001	No Sample	8608-672-007	8608-024-003	8608-024-004	1000-000-371
SW18	SW18088600	08/22/86	7.40	28	19.0	8606-056-006	8608-056-002	8608-056-002	8608-056-007	8608-056-008	1000-000-373
SWA1	SWA1088600	08/14/86	8.30	827	22.0	8608-029-001	8608-055-001	8608-055-001	8608-029-003	8608-029-004	1000-000-391
SWA2	SWA2088600	08/14/86	8.50	1500	22.0	8608-029-007	8608-055-002	8608-055-002	8608-029-009	8608-029-010	1000-000-393
SWA3	SWA3088600	08/14/86	6.90	816	25.0	8608-029-013	8608-055-003	8608-055-003	8608-028-015	8608-028-016	1000-000-394
SWA4	SWA4088600	08/14/86	7.00	318	22.0	8608-029-019	8608-055-004	8608-055-004	8608-029-021	8608-029-022	1000-000-395
SWB1	SWB1088600	08/16/86	8.40	3498	21.0	8608-033-001	8608-057-006	8608-053-006	8608-033-002	8608-033-003	1000-000-396
SWB2	SWB2088600	08/15/86	9.50	475	26.0	8608-033-006	8608-057-001	8608=053-001	8608-033-007	8608-033-008	1000-000-398
SWB3	SWB3088600	08/15/86	6.90	370	23.0	8608-033-011	8608-057-002	8608-053-002	8608-033-012	8608-033-013	1000-000-399
SWB4	SWB4088600	08/15/86	7.00	550	24.0	8608-033-016	8608-057-003	8608-053-003	8608-033-017	8608-033-018	1000-000-400
SWB5	SWB5088600	08/18/86	8.00	367	28.0	8608-036-037	8608-058-002	8608-058-002	8608-036-039	8608-036-040	1000-000-401

Modified After: Rockwell International, 1988b P. 6-10

Table 2-2

VOLATILE ORGANIC CONCENTRATIONS IN SURFACE WATER (ug/l)

Station	1,1-DCE	t1,2-DCE	$CHCl_3$	1,2-DCA	1,1,1-TCA	CCl_4	TCE	1,1,2-TCA	PCE	Acetone	MeCl
		NS	100	5	200	5	5	NS	NS	NS	NS
SW-18	<5U	<5U	<5U	<5U	<5U	<5U	2**	<5U	<5U	5_b	22
SW-17	<5U	3**	<5U	<5U	<5U	<5U	1**	<5U	<5U	<10	<5
A-1	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	3_b	1**
A-2	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	3_b	2**
A-3	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	4_b	4**
A-4	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	7_b	<5
SW-3	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<5U	<10	<5

U Signifies the detection limit.

** Estimated value, detected but below detection limit.

b Compound also detected in the blank.

Modified After: Rockwell International, 1988b p. 6-11

Table 2-3

MAJOR ION CONCENTRATIONS AND OTHER PARAMETERS FOR SURFACE WATER (mg/l)

STATION	Ca	K	Mg	Na	NO_3	HCO_3	CO_3	Cl	CN	PO_4	SO_4	TDS
					10			250	0.200		250	500
SW-18	130	3.1	29	37	<5U	12	290	29	<0.005U	1.7	58	439
SW-17	85.5	26.4	24.2	53.2	17.2	NA	NA	51	<0.001U	NA	94	530
A-1	26.9	36.9	10.8	104	<5U	NA	NA	82	<0.001U	NA	53	534
A-2	86.1	72.7	20.3	193	<5U	NA	NA	156	<0.0013U	NA	212	1070
A-3	27.4	47.1	14.6	67.1	<5U	NA	NA	69	<0.0013U	NA	152	507
A-4	16.4	15.5	4.55	14.8	<5U	NA	NA	21	<0.001U	NA	30	279
SW-03	47.5	<0.100	6.0	23.2	<5U	NA	NA	15	<0.005U	NA	39	180

U Signifies the detection limit. NA = Not Analyzed

Modified After: Rockwell International, 1988b p. 6-12

Table 2-4

METAL CONCENTRATIONS IN SURFACE WATER
(mg/l)

STATION	Al	As	Ba	Be	Cr	Cu	Fe	Hg	Mn	Mo	Pb	Se	Sr	Tl	V	Zn
	0.95	.05	1.0	.1	.05	1.0	.3	.002	.05	NS	.05	.01	NS	.015	NS	5.0
SW-18	<0.100U	<0.100U	<0.100U	<0.005U	<0.010U	<0.020U	2.17	<0.0002U	0.41	<0.10U	<0.005U	<0.005U	0.64	<0.010U	<0.050U	<0.020U
SW-17	<0.100U	<0.001U	0.340	<0.005U	<0.005U	<0.020U	<0.030U	0.0008	0.660	<0.10U	<0.005U	0.0016	0.76	0.029	<0.050U	0.090
A-1	0.150	0.002U	0.150	<0.005U	0.009	<0.020U	0.080	<0.0002U	<0.010U	<0.10U	<0.005U	<0.002U	0.20	<0.010U	<0.050U	4.21
A-2	0.580	0.002	0.170	<0.005U	0.022	<0.020U	0.240	0.0014	0.080	<0.10U	<0.005U	<0.002U	0.36	0.015	<0.005U	4.2
A-3	<0.100U	<0.001U	0.150	<0.005U	0.0091	<0.020U	<0.030U	0.00081	0.240	<0.10U	0.006	<0.002U	0.34	<0.010U	<0.050U	0.040
A-4	<0.100U	<0.001U	0.120	<0.005U	0.010	<0.020U	<0.030U	<0.0002U	0.020	<0.10U	0.008	<0.002U	0.15	<0.010U	<0.050U	0.040
SW-3	<0.100U	<0.002U	<0.100U	0.090	<0.010U	0.030	<0.075U	<0.0002U	0.020	0.300	<0.010U	<0.002U	0.36	<0.010U	0.313	0.300

U signifies the detection limit.
The following metals were not detected: Ag(0.010U), Cd (0.005U), Co (0.050U), Cs (0.100U), Ni (0.040U), and Sb (0.020U).

Modified After: Rockwell, 1988b Vol. I P. 6-13

Table 2-5

RADIONUCLIDE CONCENTRATIONS IN SURFACE WATER
(pCi/l)

STATION	GROSS ALPHA	GROSS BETA	PLUTONIUM	AMERICIUM	U^{234}	U^{238}	TRITIUM
	15	.50	40	4	40	40	20000
SW-18	4(5)	2(4)	1.9(0.5)	1.4(0.5)	-0.03(0.05)	0.04(0.04)	0.07(0.21)
SW-17	6(10)	4(5)	0.0(0.03)	0.0(0.02)	3.3(0.4)	2.9(0.4)	0.19(0.22)
A-1	10(9)	12(5)	0.24(0.14)	0.02(0.03)	1.4(0.3)	1.3(0.2)	0.16(0.22)
A-2	7(14)	23(8)	0.17(0.06)	0.05(0.04)	6.4(0.7)	5.8(0.7)	0.09(0.22)
A-3	18(10)	14(5)	0.03(0.06)	0.01(0.02)	3.0(0.4)	2.1(0.3)	0.03(0.22)
A-4	2(2)	5(2)	0.0(0.07)	0.05(0.04)	0.81(0.19)	0.49(0.16)	0.10(0.22)
SW-03	2(3)	3(3)	-0.04(0.17)	0.02(0.03)	0.63(0.22)	0.60(0.20)	-0.09(0.24)

* Units pCi/l
Parentheses indicate 2 standard deviation error

Modified After: Rockwell International, 1988b, p.

Table 2-6
SECOND QUARTER 1989 WATER LEVELS IN SURFICIAL MATERIALS

	4/89 (ft)	5/89 (ft)	6/89 (ft)
Colluvial Wells			
B208789	N/A	N/A	N/A
B208389	N/A	N/A	N/A
B210489	N/A	N/A	N/A
1886	5,877.39	5,877.09	Dry
P209989	N/A	N/A	N/A
B208089	N/A	N/A	N/A
2086	Dry	Dry	5,950.32
3386	Dry	Dry	Dry
2187	5,923.76	5,923.96	5,922.96
Alluvial Wells			
P209289	N/A	N/A	N/A
2886	5,956.47	5,957.57	5,957.77
2286	5,970.55	5,972.15	5,970.75
5687	5,972.89	5,973.39	5,973.49
P207889	N/A	N/A	N/A
2986	5,949.75	5,949.85	5,949.95
P209789	N/A	N/A	N/A
3787	5,962.12	5,962.82	5,962.52
P207689	N/A	N/A	N/A
2686	5,965.69	5,965.69	5,965.69
2486	dry	5,973.37	dry
P207489	N/A	N/A	N/A
3887	5,963.35	5,964.65	5,965.05
0406	5,967.72	5,969.52	5,968.22
Valley Fill Wells			
B208589	N/A	N/A	N/A
1586	5,841.53	5,841.63	5,840.93
1386	5,834.44	5,834.34	5,833.74
3686	5,876.48	5,877.18	5,878.08
3586	5,903.64	5,903.34	5,903.44
1786	5,860.05	5,861.45	5,860.05

Notes: 1. See Figure 2-23 for well locations in the Solar Evaporation Ponds area.
2. Datum is mean sea level.
3. N/A is defined as not available.

Table 2-7
FOURTH QUARTER 1989 WATER LEVELS IN SURFICIAL MATERIALS

	10/89 (ft)	11/89 (ft)	12/89 (ft)
Colluvial Wells			
B208789	N/A	N/A	N/A
B208389	N/A	N/A	N/A
B210489	N/A	N/A	N/A
1886	N/A	N/A	Dry
P209989	N/A	N/A	N/A
B208089	N/A	N/A	N/A
2086	N/A	Dry	N/A
3386	N/A	Dry	N/A
2187	N/A	5,922.31	N/A
Alluvial Wells			
P209289	N/A	N/A	N/A
2886	5,956.57	N/A	N/A
2286	N/A	5,969.72	N/A
5687	N/A	5,971.69	N/A
P207889	N/A	N/A	N/A
2986	Dry	N/A	N/A
P209789	N/A	N/A	N/A
3787	N/A	5,961.02	N/A
P207689	N/A	N/A	N/A
2686	N/A	Dry	N/A
2486	N/A	Dry	N/A
P207489	N/A	N/A	N/A
3887	N/A	5,964.00	N/A
0406	N/A	5,966.41	N/A
Valley Fill Wells			
B208589	N/A	N/A	N/A
1586	N/A	5,840.85	N/A
1386	N/A	5,831.08	N/A
3686	N/A	N/A	5,877.62
3586	N/A	N/A	5,901.95
1786	N/A	N/A	5,860.81

Notes: 1. See Figure 2-24 for well locations in the Solar Evaporation Ponds area.
2. Datum is mean sea level.
3. N/A is defined as not available.

Table 2-8
RESULTS OF HYDRAULIC CONDUCTIVITY TESTS OF SURFICIAL MATERIALS

Well Number	Formation	Lithology Screened	Drawdown Recovery Test cm/s
17-86	Q_{VF}	Gravel	$4.8x10^{-6}$
22-86	Q_{RF}	Gravel	$8.7x10^{-6}$
26-86	Q_D	Gravel and Sand	$4x10^{-8}$

After: Rockwell International, 1988b Vol. I, P. 5-13

Table 2-9
VERTICAL GRADIENTS

WELL	ELEVATION OF POTENTIOMETRIC SURFACE & DATE	WATER LEVEL DIFFERENCE (ft)	ELEVATION OF SCREENED INTERVAL	ELEVATION OF SATURATED INTERVAL MIDPOINT	SEPARATOR THICKNESS (ft)	DOWNWARD VERTICAL GRADIENT
14-86*	5836.61 (04/11/88)	4.62	5805.29-5789.35	5797.32	38.76	0.12
15-86	5841.23 (04/11/88)		5841.52-5830.92	5836.08		
16-86*	5861.00 (04/11/88)	0.35	5825.68-5819.68	5822.68	33.64	0.01
17-86	5861.35 (04/11/88)		5861.52-5851.28	5856.32		
21-87	5921.56 (04/18/88)	69.57	5924.33-5917.18	5919.37	73.60	0.95
22-87BR*	5851.99 (04/18/88)		5849.29-5842.24	5845.77		
25-86*	5935.85 (04/18/88)	30.24	5914.55-5892.45	5903.50	61.29	0.49
26-86	5966.09 (04/18/88)		5970.73-5963.48	5964.79		
27-86*	5863.96 (04/18/88)	94.11	5833.36-5828.86	5831.11	124.24	0.05
28-86	5958.07 (04/18/88)		5957.20-5952.63	5955.35		
34-86*	5890.88 (04/18/88)	13.66	5866.20-5854.19	5860.20	40.87	0.33
35-86	5904.54 (04/18/88)		5904.34-5897.60	5901.07		

* Completed in Bedrock
( ) Date of water level measurement

After: Rockwell International, 1988b Vol.I P. 5-39

Table 2-10
RESULTS OF HYDRAULIC CONDUCTIVITY TESTS IN ARAPAHOE FORMATION

Well	Lithology	Drawdown Recovery Test (cm/s)	Slug Test (cm/s)	Packer Test (cm/s)
14-86	Sandstone	1.9×10^{-7}		2.2×10^{-6}
	Claystone			1.3×10^{-6}
16-86	Siltstone & Sandstone*	6×10^{-8}		
	Siltstone			6.1×10^{-7}
	Claystone			5.3×10^{-6}
23-86	Sandstone		1×10^{-8}	
	Siltstone			6.9×10^{-7}
	Claystone			2.4×10^{-7}
25-86	Claystone & Sandstone*	7×10^{-8}		
	Sandstone			3.4×10^{-7}
	Claystone			1.2×10^{-7}
27-86	Sandstone	1.9×10^{-7}		
	Siltstone			1.4×10^{-7}
	Claystone			2.4×10^{-7}
32-86	Sandstone & Claystone*	9×10^{-8}		
	Claystone			2.2×10^{-7}
34-86	Sandstone	3.1×10^{-6}		3.3×10^{-6}
	Claystone			1.3×10^{-6}
	Geometric Mean (cm/s)			
	Sandstone:	4.8×10^{-7}	1×10^{-8}	1.4×10^{-6}
	Siltstone:			3.9×10^{-7}
	Claystone:			5.4×10^{-7}

* Mixed lithology tests not used in calculating geometric means.

After: Rockwell International, 1988b Vol. I P. 5-43

EXPLANATION FOR TABLES 2-11 AND 2-12

ND	=	Not Detected
a	=	Data in this table is summarized from the best available copy (Rockwell, 1988b, Vol. II p. 4-2). This table has not been checked against the original data sheets.
( )*	=	Units Shown on Data Provided for Sludge in Pond 207-A
( )	=	Test Results Reference Ranging from 1 to 10, Described below:

1 Summary of Quarterly Sampling 1984 and 1985, Appendix 3, Table 3-1

2 Summary of Weekly Sampling for Ponds 207-B North and Center Liquids, Appendix 3, Table 3-II

3 Summary of Two Sets of Metals Analyses of Ponds 207-B North and Center Liquids, October 1984 and April 1985, Appendix 3, Table 3-III.

4 Summary of Radiochemical Analyses, April and May 1986, Appendix 4, Table 4-I

5 Summary of Metals and Phenols Testing April and May 1986, Appendix 4, Table 4-II

6 Summary of Parameters monitored in Pond 207-A Sludge in May 1985, Appendix 4, Table 4-III

7 207-B Solar Pond North and Center Quarterly Metals Analysis, August 14, 1987, Lab No. E87-3918, Appendix 4

8 207-B Solar Pond North and Center Quarterly Metals Analysis, November 30, 1987, Lab No. E87-4254, Appendix 4

9 207-A and 207-C Solar Pond Quarterly Analysis Results (Liquids), March 1987 to March 1988, Appendix 4

10 207-B Solar Pond Weekly Analysis Results (Liquids), October 1987 to June 1988.

Table 2-11
ANALYTICAL RESULTS FROM SOLAR EVAPORATION POND LIQUID SAMPLES

ANALYTE	UNITS	POND 207-A	POND 207-B NORTH	POND 207-B CENTER	POND 207-B SOUTH	POND 207-C
pH		(1) 8.3 - 11.0 (9) 10.1	(2) 7.5 - 9.6 (10) 8.0 - 8.5	(2) 7.3 - 11.3 (10) 9.6 - 10.5	---- ----	(1) 7.7 - 12.5 (9) 10.5 - 11.3
Nitrate as N	(mg/l)	(1) ND - 21,739 (9) 19,200	(2) 335 - 1,367 (10) 212 - 507	(2) ND - 15.6 (10) 346.4 - 1221	---- ----	(1) 8.4 - 18,841 9,650 - 21,400
TDS	(mg/l)	(9) 127,000	----	----	----	(9) 93,859 - 175,000
Cyanide	(mg/l)	(1) ND - 1.7 (9) 0.1	----	----	----	(1) ND - 1.9 (9) 8.48 - 8.5
Gross Alpha	(pCi/l)	(1) 32 (16) - 56,000 (0 0) (4) 46,000 (4,000) - 80,000 (6,000) (9) 80,000 (1,000)	(2) 13 (50) - 323 (33) (4) 74 (50) - 120 (50) (10) 52 (20) - 200 (88)	(2) 4 (8) - 59 (23) (10) 57 (21) - 2,500 (400)	----	(1) 10,000 (17,000) - 15,000 (3,000) (9) 13,000 (1,000) - 46,000 (8,000)
Gross Beta	(pCi/l)	(1) 2 (27) - 27,000 (600) (4) 35,000 (2,000) - 40,000 (2,000) (9) 2,100 (200)	(2) 5 (25) - 163 (25) (4) 56 (32) - 100 (92) (10) 67 (3) - 200 (80)	(2) 8 (11) - 73 (8) (10) 72 (16) - 1,500 (200)	----	(1) 405 (79) - 11,000 (2,000) (9) 3,400 (100) - 44,000 (4,000)
Pu. Plutonium 239	(pCi/l)	(1) 0.0 (420) - 240 (100) (4) 56 (16) - 660 (50)	(4) ND	----	----	(1) 210 (320) - 1,400 (300) (9) 300 (138) - 2,100 (300)
Am. Americium 241	(pCi/l)	(1) 0.0 (1,000) - 200 (120) (4) ND - 45 (14)	(4) ND	----	----	(1) 12 - 13.0 (1.00) (9) 0.0 (27) - 2,900 (300)
U. Uranium	(pCi/l)	(1) 0.69 (0.79) - 26,000 (2,000)	----	----	----	(1) 1,000 (300) - 15,000 (1,000) (9) 1,400 (900) - 40,000 (2,000)
					-----	-----

After: Rockwell, 1988b C Vol. II P. 4-2

Table 2-11
(continued)

ANALYTE	UNITS	POND 207-A	POND 207-B NORTH	POND 207-B CENTER	POND 207-B SOUTH	POND 207-C
		(8) .09	(8) .071			
Cd, Cadmium	(mg/l)	(5) 0.070 - 0.150	(5) ND (7) < 0.01 (8) .01	(7) < 0.01 (8) .01	----	----
Ca, Calcium	(mg/l)	(5) ND	(3) 20.0 (3) 290 (5) 176 - 198 (7) 96.0 (8) 180.0	(3) 2.9 (3) 45.0 (7) 95.0 (8) 66.0	----	----
Ce. Cerium	(mg/l)	----	(7) < 2.8 (8) < 3.0	(7) < 3.2 (8) < 3.5	----	----
Cs. Cesium	(mg/l)	----	(3) ND (3) ND (7) < 28 (8) < 3.0	(3) ND (3) 0.041 (7) < 32 (8) .35	----	----
Co, Cobalt	(mg/l)	(5) 0.200 - 0.500	(5) ND (7) < 0.014 (8) < 0.015	(7) < 0.016 (8) < 0.018	----	----
Cr, Chromium	(mg/l)	(5) 137 - 167 (7) < 0.05 (8) < 0.05	(7) < 0.05 (8) < 0.05	----	----	----
Cu, Copper	(mg/l)	(5) 1.61 - 1.80	(3) ND (3) ND (5) ND (7) < 0.014 (8) < 0.015	(3) 0.016 (3) 0.037 (7) < 0.016 (8) < 0.018	----	----
Ge, Germanium	(mg/l)	----	(7) < 0.014 (8) < 0.015	(7) < 0.016 (8) < 0.018	----	----
Fe, Iron	(mg/l)	(5) 1.50 - 8.00	(3) 0.28	(3) 0.074	----	----

After: Rockwell, 1988b C Vol. II P. 4-3

Table 2-11
(continued)

ANALYTE	UNITS	POND 207-A	POND 207-B NORTH	POND 207-B CENTER	POND 207-B SOUTH	POND 207-C
U 233+234 U 238	(pCi/l) (pCi/l)	(4) 14,000 (1,000) - 20,000 (1,000) (4) 21,000 (1,000) - 28,000 (1,000)	(4) 50 (2) - 53 (2) (4) 31 (1) - 33 (1)	---- ----	---- ----	---- ----
Tritium	(pCi/l)	(1) 620 (230) - 3,000 (800) (4) 240 (180) - 930 (260)	(4) 1,200 (300) - 1,300 (300)	----	----	(1) 0.0 (0.0) - 6,400 (600)
Al. Aluminum	(mg/l)	(5) 2.31 - 2.64	(3) 0.16 (3) 1 (5) ND (7) < .0028 (8) < .003	(3) 0.15 (3) 2 (7) < .0032 (8) < .0035	----	----
Sb. Antimony	(mg/l)	----	(7) < 0.028 (8) < 0.03	(7) < 0.032 (8) < 0.035	----	----
As. Arsenic	(mg/l)	(5) 0.150	(5) ND (7) < 0.01 (8) < 0.01	(7) < 0.01 (8) < 0.01	----	----
Ba, Barium	(mg/l)	(5) ND	(5) ND - 0.220 (7) < 1.0 (8) < 1.0	(7) < 1.0 (8) < 1.0	----	----
Be. Beryllium	(mg/l)	(1) ND - 0.1 (5) 0.027 - 0.043 (9) .002	(5) ND (7) <0.05 (8) .06	(7) <0.05 (8) < 0.05	----	(1) ND - 0.6 (9) 0.1
Bi, Bismuth	(mg/l)	----	(7) < 0.014 (8) < 0.015	(7) < 0.016 (8) < 0.018	----	----
B, Boron	(mg/l)	(3) 0.29 (3) 0.31 (7) 14	(3) 0.24 (3) 0.67 (7) 0.13	----	----	
					-----	-----

After: Rockwell, 1988b Vol. II P. 4-4

Table 2-11
(continued)

ANALYTE	UNITS	POND 207-A	POND 207-B NORTH	POND 207-B CENTER	POND 207-B SOUTH	POND 207-C
			(3) 0.29 (5) ND (7) .057 (8) < 0.003	(3) 0.2 (7) 0.13 (8) < 0.0035		
Pb, Lead	(mg/l)	(5) ND	(3) ND (3) 0.0035 (5) ND (7) < 0.0028 (8) < 0.003	(3) ND (3) 0.002 (7) < 0.0032 (8) < 0.0035	----	----
Li, Lithium	(mg/l)	----	(3) 0.37 (3) 3.5 (7) 1.7 (8) 6	(3) 0.052 (3) 0.41 (7) 2.9 (8) 3.5	----	----
Mn, Manganese	(mg/l)	(3) ND (3) ND (5) ND - 0.015 (7) < 0.0028 (8) < 0.003	(3) 0.022 (3) 0.001 (7) < 0.0032 (8) < 0.0035	----	----	----
Mg, Magnesium	(mg/l)	(5) ND	(3) 87.0 (3) 120.0 (5) 66.4 - 72.6 (7) 88 (8) 80.0	(3) 3.9 (3) 13.0 (7) 86.0 (8) 91.0	----	----
Hg, Mercury	(mg/l)	(5) ND - 0.0002	(5) ND (7) < 0.002 (8) < 0.002	(7) < 0.002 (8) < 0.002	----	----
Mo. Molybdemum	(mg/l)	----	(3) ND (3) 0.0069 (7) < 0.0028 (8) .003	(3) 0.016 (3) 0.037 (7) .019 (8) .0035	----	----
Ni, Nickel	(mg/l)	(5) 1.90 - 2.00	(3) ND (3) ND (5) ND - 0.050 (7) < 0.0028	(3) 0.015 (3) 0.016 (7) < 0.032 (8) < 0.035	----	----
					-----	-----

After: Rockwell, 1988b C Vol. II P. 4-5

Table 2-11
(continued)

ANALYTE	UNITS	POND 207-A	POND 207-B NORTH	POND 207-B CENTER	POND 207-B SOUTH	POND 207-C
			(8) < 0.03			
Nb. Niobium	(mg/l)	----	(7) < 0.14 (8) < 0.15	(7) < 0.16 (8) <0.18	----	----
P, Phosphorous	(mg/l)	----	(3) ND (3) ND (7) < 0.14 (8) < 0.15	(3) 0.074 (3) 0.2 (7) < 0.16 (8) 8.18	----	----
K, Potassium	(mg/l)	(5) 13,200 - 14,300	(3) 82.0 (3) 120 (5) 56.1 - 62.7 (7) 89.0 (8) 64.0	(3) 30.0 (3) 36.0 (7) 98.0 (8) 110.0	----	----
Rb, Rubidium	(mg/l)	----	(7) < 28 (8) < 3	(7) < 0.32 (8) < 0.35	----	----
Se, Sellinium	(mg/l)	(5) ND	(3) 0.01 (3) 0.02 (5) 0.009 (7) < 0.01 (8) .024	(3) ND (3) ND (7) < 0.01 (8) .019	----	----
Si, Silicon	(mg/l)	----	(3) 2.1 (3) 5.6 (7) 2.1 (8) < 0.5	(3) 2.4 (3) 5.5 (7) 1.4 (8) 1.6	----	----
Ag, Silver	(mg/l)	----	(3) ND (3) 0.002 (5) ND (7) < 0.0028 (8) < 0.003	(3) 0.0016 (3) 0.015 (7) < 0.0032 (8) < 0.0035	----	----
NÅ, Sodium	(mg/l)	(5) 36,300 - 42,900	(3) 370.0 (3) 620.0	(3) 67.0 (3) 250.0	----	----

After: Rockwell, 1988b C Vol. II P. 4-6

Table 2-11
(continued)

ANALYTE	UNITS	POND 207-A	POND 207-B NORTH	POND 207-B CENTER	POND 207-B SOUTH	POND 207-C
			(5) 363 - 451 (7) 820 (8) 770.0	(7) 800.0 (8) 650.0		
Sr, Strontium	(mg/l)	----	(3) 1.2 (3) 3.5 (7) 0.14 (8) 21	(3) 0.28 (3) 0.52 (7) .16 (8) .14	----	----
Ta. Tantalum	(mg/l)	----	(7) < 0.02 (8) < 0.03	(7) < 0.032 (8) < 0.035	----	----
Te, Tellurium	(mg/l)	----	(7) < 0.28 (8) < 0.3	(7) < 0.32 (8) < 0.35	----	----
Tl, Thallium	(mg/l)	----	(7) < 0.014 (8) < 0.015	(7) < 0.016 (8) < 0.018	----	----
Tb, Thorium	(mg/l)	----	(7) < 0.02 (8) < 0.03	(7) < 0.32 (8) < 0.35	----	----
Sm, Tin	(mg/l)	(5) 7.00 - 13.00	(5) ND (7) < 0.028 (8) < 0.03	(7) < 0.032 (8) < 0.035	----	----
Ti, Titanium	(mg/l)	----	(7) < 0.014 (8) < 0.015	(7) < 0.816 (8) < 0.018	----	----
W, Tungsten	(mg/l)	----	(7) < 1.4 (8) < 1.5	(7) < 1.6 (8) < 1.8	----	----
U, Uranium	(mg/l)	----	(7) < 1.4 (8) < 1.5	(7) < 1.6 (8) < 1.8	----	----
V, Vanadium	(mg/l)	(5) 0.10 - 0.20	(3) ND (3) ND (5) ND (7) < 0.028 (8) < 0.03	(3) ND (3) 0.0001 (7) < 0.032 (8) < 0.035	----	----

After: Rockwell, 1988b Vol. II P. 4-7

Table 2-11
(continued)

ANALYTE	UNITS	POND 207-A	POND 207-B NORTH	POND 207-B CENTER	POND 207-B SOUTH	POND 207-C
Zn, Zinc	(mg/l)	(5) 0.62 - 0.78	(3) ND (3) ND (5) ND - 0.022 (7) < 0.14 (8) < 0.15	(3) 0.041 (3) ND (7) < 0.16 (8) < 0.18	----	----
Zr, Zirconium	(mg/l)	----	(3) ND (3) ND (7) < 0.028 (8) < 0.03	(3) 0.0041 (3) ND (7) < 0.032 (8) < 0.035	----	----
Tritium	(mg/l)	-----	(3) ND (3) 0.069	(3) 0.022 (3) 0.041	----	----
Phenols	(mg/l)	(5) 0.013 - 0.035	(5) 0.003 - 0.046	----	----	----

After: Rockwell, 1988b C Vol. II P. 4-6

Table 2-12
ANALYTICAL RESULTS FROM
SOLAR EVAPORATION POND SLUDGE SAMPLES
SLUDGE CHARACTERIZATION SUMMARY 1984 TO 1988

Analyte	Units	Pond 207-A
ph		(6) 9.5
Nitrate as nitrogen	(mg/l)	(6) 8.80
Gross alpha	(pCi/l) (pCi/l)	(4) 4.70 (2.0) - 11.0 (1.0) (6) 860.0
Gross beta	(pCi/l)	(4) 160.0 (20.0) - 1.10 (100)
Plutonium 239	(pCi/l)	(4) 1.0 (100) - 3.7 (100)
Americium 241	(pCi/l)	(4) 1.10 (200) - 4.40 (100)
Uranium 233, 234	(pCi/l)	(4) 70 (10) - 570 (30)
Uranium 235	(pCi/l)	(6) 24 (19)
Uranium 238	(pCi/l) (pCi/l)	(4) 130 (10) - 480 (30) (6) 520 (90)
Tritium	(pCi/l)	(4) 1.30 (500) - 12.0 (1.0)
Aluminum	(mg/kg)	(5) 11.0 - 11.9
Arsenic	(mg/kg)	(5) ND
Barium	(mg/kg)	(5) ND
Beryllium	(mg/kg) (mg/kg)	(5) 309 - 1.57 (6) 170
Cadmium	(mg/kg)	(5) 1.11 - 10.5
Calcium	(mg/kg)	(5) 19.6 - 50.0
Cobalt	(mg/kg)	(5) ND
Chromium (total)	(mg/kg)	(5) 1.01 - 19.7
Chromium (dissolved)	(mg/kg)	(6) <1.0
Copper	(mg/kg)	(5) 425 - 1.59
Iron	(mg/kg)	(5) 3.59 - 6.90
Lead	(mg/kg)	(5) 65.0 - 455.0
Manganese	(mg/kg)	(5) 153.0 - 595.0
Magnesium	(mg/kg)	(5) 6.10 - 21.0

Table 2-12
ANALYTICAL RESULTS FROM
SOLAR EVAPORATION POND SLUDGE SAMPLES
SLUDGE CHARACTERIZATION SUMMARY 1984 TO 1988
(continued)

Analyte	Units	Pond 207-A
Mercury	(mg/kg)	(5) 7.50 - 25.0
Nickel	(mg/kg)	(5) 124.0 - 1.32
Potassium	(mg/kg)	(5) 50.0 - 65.3
Sellinium	(mg/kg)	(5) ND
Silver	(mg/kg)	(5) 153.0 - 237.0
Sodium	(mg/kg)	(5) 130.0 - 166.0
Tin	(mg/kg)	(5) ND
Vanadium	(mg/kg)	(5) ND
Zinc	(mg/kg)	(5) 277.0 - 595.0
Phenols	(mg/kg)	(5) ND - 3.30

Note: No sludge characterization data is available for the other Solar Evaporation Ponds.

Table 2-13
METAL AND RADIONUCLIDE CONCENTRATIONS IN BACKGROUND SOIL

Metals	Concentration (mg/kg)
Aluminum	6,540-9,140
Antimony	41U
Arsenic	6.1U-10
Barium	135U
Beryllium	3.4U
Calcium	2,500U
Cadmium	3.4U
Chromium (Total)	5.6-13
Cobalt	12U-25
Copper	12U
Iron	9,080-12,400
Lead	15-48
Magnesium	2,500U
Manganese	196-337
Mercury	0.1U
Nickel	20U
Potassium	2,500U
Selenium	3.4U
Silver	5U
Sodium	2,500U
Thallium	6.8U
Tin	41U
Vanadium	30U-38
Zinc	20-49

Radionuclides	Concentration (pCi/g)
Plutonium	0.01(0.10)-0.10(0.20)
Americium	-0.02(0.03)-0.28(0.16)
Uranium 233+234	0.66(0.16)-1.4(0.20)
Uranium 238	0.62(0.16)-1.2(0.2)
Tritium	-70(220)-280(270)

Notes:
1. Background values based on nine composite samples collected from the top 1 foot of Rocky Flats Alluvium in the West Buffer Zone.
2. "U" indicates values less than detection limits.
3. Values in parentheses indicate counting uncertainty.
4. Tritium is in units of pCi/l of soil water.

After: Rockwell, 1988b Vol. II P. 4-10

Table 2-14
METAL CONCENTRATION IN SOILS ABOVE ESTIMATED BACKGROUND LEVELS (mg/kg)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Al (9140)	As (10)	Ba (135u)	Ca (2500u)	Co (25)	Cr (13)	Cu (13u)	Fe (12,400)	Hg (0.1U)	K (2500)
SP01-87	SP018700FS	0.0-1.2	13,442	-	-	10,348*	-	21	-	15,797	-	-
	SP018704DH	4.0-5.0	14,499	-	-	8,663*	-	16	-	14,220	-	-
	SP018705DH	5.0-6.3	30,899*	-	-	14,409*	-	28	-	23,226	-	-
	SP018711DH	10.5-12.2	9,166	-	-	-	-	18	-	16,421	-	-
	SP018713DH	12.7-14.9	-	-	-	-	-	-	-	-	-	-
	SP018716BR (WT)	15.2-16.7	-	-	-	-	-	-	-	-	-	-
	SP018721DH	20.2-22.3	-	-	-	3,080	-	-	-	14,745	-	-
	SP018723DH	22.7-24.1	-	-	-	3,332	-	31	30	13,806	-	-
SP02-87	SP02870008	0.0-10.1	-	-	-	18,390*	-	-	-	15,043	-	-
	SP028708UC	7.1-10.1	-	-	-	126,076*	-	-	-	-	-	-
	SP028711CT	10.1-12.6	-	-	-	50,605*	-	-	-	-	-	-
	SP028713BR	12.6-15.1	-	-	-	26,297*	-	-	-	-	-	-
SP03-87	SP038702DH	2.0-3.5	NA	-	NA	NA	-	NA	NA	NA	-	NA
	SP038703FS	4.0-4.6	NA	NA	NA	NA	-	NA	NA	NA	-	NA
	SP038711DH	10.3-11.6	9,691	-	-	-	-	-	-	-	-	-
	SP038713CT	12.8-14.4	-	-	-	2,523	-	-	-	-	-	-
	SP038716BR	15.2-16.9	10,704	11	-	-	-	-	-	-	-	-
SP04-87	SP048702DH	2.0-3.7	-	-	-	-	-	-	-	-	-	-
	SP048704DH	4.0-5.8	18,764	-	174	119,858*	-	17	-	12,419	-	3,500
	SP0487004D	4.0-5.8	20,345	-	200	81,473*	-	22	-	13,052	-	5,200
	SP048707DH	7.0-8.7	9,576	NA	170	161,428*	-	-	-	-	-	-
	SP048710DH	9.5-10.1	NA	NA	NA	-	-	NA	NA	NA	-	NA
	SP048712DH (WT)	12.6-14.5	-	15	-	11,991*	-	-	21	23,702	-	-
	SP048715FS	14.5-17.0	-	-	-	-	-	-	-	-	-	-
	SP048717DH	17.0-19.5	10,908	18	-	3,578	-	-	17	-	-	-
	SP048720DH	19.5-22.0	-	-	-	3,097	-	-	-	-	-	-
	SP048722DH	22.0-24.0	-	-	-	-	-	-	-	-	-	-
	SP048725DH	24.5-27.0	-	-	-	3,640	-	-	19	-	-	-
	SP048727DH	27.0-29.5	-	-	119*	38,269*	-	-	-	-	-	-
	SP048730DH	29.5-32.0	-	-	-	2,583	-	-	-	-	-	-
	SP048732DH	32.0-34.0	-	27	-	-	-	-	-	-	-	-

Alter: Rockwell, 1988b Vol. II P. 4-14

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Mg (2500)	Mn (337)	Ni (20u)**	V (38)	Zn (49)	Be (3.4U)	Cd (3.4U)	Sb (41U)	Tl (6.8U)
SP01-87	SP018700FS	0.0-1.2	2,731	-	-	42	61	-	3.74	-	-
	SP018704DH	4.0-5.0	2,801	-	-	53	54	-	-	-	-
	SP018705DH	5.0-6.3	2,799	-	30	72	-	-	-	-	-
	SP018711DH	10.5-12.2	-	-	-	-	-	-	-	-	-
	SP018713DH	12.7-14.9	-	408	35	-	-	-	-	-	-
	SP018716BR (WT)	15.2-16.7	-	-	-	40	-	-	-	-	-
	SP018721DH	20.2-22.3	-	-	-	42	55	-	-	-	-
	SP018723DH	22.7-24.1	-	-	39	-	51	-	-	-	-
SP02-87	SP02870008	0.0-10.1	-	-	-	-	-	-	-	-	-
	SP028708UC	7.1-13.1	3,514	-	-	-	-	-	5.07	-	-
	SP028711CT	10.1-12.6	-	-	-	-	-	-	3.51	-	-
	SP028713BR	12.6-15.1	-	-	-	-	-	-	-	-	-
SP03-87	SP038702DH	2.0-3.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP038703FS	4.0-4.6	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP038711DH	10.3-11.6	-	-	-	-	-	-	-	-	-
	SP038713CT	12.8-14.4	-	-	-	-	-	-	-	-	-
	SP038716BR	15.2-16.9	-	-	-	-	-	-	-	-	-
SP04-87	SP048702DH	2.0-3.7	-	-	-	-	-	-	51.10*	-	-
	SP048704DH	4.0-5.8	3,916	-	38	-	-	-	70.85*	-	-
	SP0487004D	4.0-5.8	3,681	-	59	-	-	-	119.14*	-	-
	SP048707DH	7.0-8.7	3,951	NA	-	-	-	-	7.41	-	-
	SP048710DH	9.5-10.1	NA	-	NA	-	-	NA	NA	NA	NA
	SP048712DH (WT)	12.6-14.5	-	-	-	50	80	-	-	-	-
	SP048715FS	14.5-17.0	-	-	-	-	54	3.75	-	-	-
	SP048717DH	17.0-19.5	2,598	-	-	-	-	-	-	-	-
	SP048720DH	19.5-22.0	-	-	-	-	-	-	-	-	-
	SP048722DH	22.0-24.0	-	-	-	-	-	-	-	-	-
	SP048725DH	24.5-27.0	-	-	-	-	-	-	-	-	-
	SP048727DH	27.0-29.5	-	-	-	-	-	-	-	-	-
	SP048730DH	29.5-32.0	-	-	30	-	50	-	-	-	-
	SP048732DH	32.0-34.0	-	-	-	-	-	-	-	-	-

After: Rockwell, 1988b Vol. II P. 4-15

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Al (9140)	As (10)	Ba (135u)	Ca (2500u)	Co (25)	Cr (13)	Cu (13u)	Fe (12,400)	Hg (0.1U)	K (2500)
SP05-87	SP0587000H	0.0-0.4	NA	NA	NA	NA	-	NA	NA	NA	-	NA
	SP058702DH	2.0-3.3	10,142	30	166	-	-	14	58*	12,536	-	2,600
	SP058704DH	4.0-5.6	11,242	15	-	-	-	15	33	13,183	-	2,600
	SP058707DH	7.0-8.3	16,123	-	-	90,980*	-	15	-	19,069	-	2,700
	SP058710DH	9.5-10.1	9,276	-	202	48,641	-	780*	23	15,349	-	3,900
	SP058712DH (WT)	12.8-14.4	10,905	-	-	20,810	-	132*	22	14,482	-	3,800
	SP058716DH	15.3-17.3	-	-	-	7,403	-	11	15	-	-	3,400
SP06-87	SP068702FS	2.0-3.7	17,725	35*	152	109,942*	-	16	-	12,790	-	-
	SP068708DH	8.0-10.4	12,522	16	-	2,619	-	-	-	13,334	-	3,300
	SP068711DH	10.5-12.4	-	-	153	143,650*	-	-	-	-	-	-
	SP068713DH	13.0-14.3	-	11	-	8,907*	-	-	-	-	-	-
	SP068716DH	15.5-17.7	-	-	-	12,081*	-	-	-	-	-	-
	SP068718DH	18.0-20.5	11,479	-	-	48,271*	-	14	24	14,390	-	-
	SP068721DH	20.5-23.0	13,630	17	-	8,135*	-	17	18	-	-	-
	SP068724DH	23.2-25.7	11,921	29	-	2,725	-	40*	30	17,706	-	-
	SP068726DH	25.7-28.2	14,799	19	-	3,318	-	22	23	-	-	-
SP07-87	SP078700DH	0.0-1.8	24,579	-	-	48,884*	-	22	44*	17,302	-	-
	SP078702DH	2.0-3.8	16,435	-	-	10,644*	-	21	-	12,694	-	-
	SP078708FS	8.0-10.3	30,265*	12	163	44,679*	-	25	26	21,846	-	-
	SP078711DH	10.5-12.2	9,232	-	-	-	-	-	-	-	-	-
	SP078713DH	13.0-14.8	22,724	-	148	3,155	-	22	21	23,823	-	-
	SP078716DH	15.5-16.7	-	-	-	56,105*	-	586*	23	13,444	-	-
	SP078718WT (WT)	18.0-19.3	-	-	-	5,205	-	393*	20	13,996	-	-
	SP078721CT	20.5-23.0	12,140	29	-	-	-	92*	29	13,349	-	-
	SP078723BR	23.0-26.0	10,902	64*	-	4,183	-	15	21	-	-	-
	SP078726DH	26.0-28.5	14,759	55*	-	4,894	-	24	23	-	-	-
39-87/ SP08-87	SP088703UC	3.5-6.5	-	-	-	6,322	-	-	-	-	-	3,000
	SP088706CT	6.5-8.5	-	-	-	-	-	-	-	-	-	3,500
	SP088709BR	9.0-11.5	-	-	-	-	-	-	-	-	-	-
SP09-87	SP098703UC	3.0-5.1	10,308	-	-	39,908*	-	-	17	16,334	-	-
	SP098706CT	6.0-8.5	-	-	-	2,836	-	-	15	-	-	-
	SP098708BR	8.5-11.0	10,202	-	-	4,141	-	-	20	-	-	-

After: Rockwell, 1988b Vol. II P. 4-16

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Mg (2500)	Mn (337)	Ni (20u)**	V (38)	Zn (49)	Be (3.4U)	Cd (3.4U)	Sb (41U)	Tl (6.8U)
SP05-87	SP058700DH	0.0-0.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP058702DH	2.0-3.3	-	-	-	47	-	-	16.45*	-	-
	SP058704DH	4.0-5.6	-	-	-	44	-	-	10.47*	-	-
	SP058707DH	7.0-8.3	3,110	509	-	-	-	-	83.68*	-	-
	SP058710DH	9.5-10.1	-	802	474*	-	-	-	21.97*	-	-
	SP058712DH (WT)	12.8-14.4	-	-	-	-	-	-	19.96*	-	-
	SP058716DH	15.3-17.3	-	-	-	-	-	-	7.30	-	-
SP06-87	SP068702FS	2.0-3.7	3,828	-	-	44	-	5.22	5.07	-	-
	SP068708DH	8.0-10.4	-	-	-	-	-	-	-	-	-
	SP068711DH	10.5-12.4	3,628	-	-	-	-	-	4.45	-	-
	SP068713DH	13.0-14.3	-	-	-	-	-	-	-	-	-
	SP068716DH	15.5-17.7	-	-	-	-	61	-	-	-	-
	SP068718DH	18.0-20.5	5,217	-	-	43	73	-	3.62	-	-
	SP068721DH	20.5-23.0	4,063	-	-	43	-	-	-	-	-
	SP068724DH	23.2-25.7	3,524	-	28	-	114	-	-	-	-
	SP068726DH	25.7-28.2	4,386	-	-	-	74	-	-	-	-
SP07-87	SP078700DH	0.0-1.8	3,397	-	29	50	51	-	8.01	-	-
	SP078702DH	2.0-3.8	-	-	-	47	-	-	-	-	-
	SP078708FS	8.0-10.3	3,587	-	58	41	52	-	-	-	-
	SP078711DH	10.5-12.2	-	-	-	-	-	-	-	-	-
	SP078713DH	13.0-14.8	-	-	49	49	68	-	-	-	-
	SP078716DH	15.5-16.7	2,518	-	514*	-	-	-	3.88	-	-
	SP078718WT (WT)	18.0-19.3	-	-	313*	-	-	-	-	-	-
	SP078721CT	20.5-23.0	3,030	-	94*	-	64	-	-	-	-
	SP078723BR	23.0-26.0	3,105	-	-	-	60	-	-	-	-
	SP078726DH	26.0-28.5	2,960	-	-	-	-	-	-	-	-
39-87/ SP08-87	SP088703UC	3.5-6.5	-	-	-	-	-	-	-	-	-
	SP088706CT	6.5-8.5	-	-	-	-	-	-	-	-	-
	SP088709BR	9.0-11.5	-	-	-	-	-	-	-	-	-
SP09-87	SP098703UC	3.0-5.1	2,951	-	-	-	50	-	-	-	-
	SP098706CT	6.0-8.5	-	-	-	-	-	4.48	-	-	-
	SP098708BR	8.5-11.0	2,542	-	-	-	-	-	-	-	-

After: Rockwell, 1988b Vol. II P. 4-17

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Al (9140)	As (10)	Ba (135u)	Ca (2500u)	Co (25)	Cr (13)	Cu (13u)	Fe (12,400)	Hg (0.1U)	K (2500)
SP10-87	SP108700DH	0.0-1.8	10,997	NA	-	17,391*	-	-	-	-	-	3,600
	SP108702DH	2.0-3.9	9,562	NA	166	39,224*	-	-	18	17,124	-	-
	SP108704BR	4.0-5.0	-	-	-	20,445*	-	-	22	35,795	-	-
	SP108705DH	5.0-7.0	-	-	-	13,618*	-	-	22	27,515	-	-
	SP108707DH	7.0-9.0	-	-	-	-	-	-	-	-	-	-
	SP108709DH	9.0-11.0	10,614	NA	-	NA	-	-	NA	-	-	NA
	SP108711DH	11.0-13.0	-	-	-	4,153	-	-	15	-	-	-
	SP108713DH	13.0-14.9	-	-	-	3,546	-	-	-	-	-	-
	SP108715DH	15.0-16.9	-	-	-	-	-	-	-	-	-	-
	SP108717DH	17.0-19.0	-	-	-	3,452	-	-	-	-	-	-
	SP1087017D	17.0-19.0	9,461	-	-	4 379	-	-	-	-	-	-
	SP108719DH	19.0-21.0	15,699	-	-	6,820	-	15	17	-	-	-
	SP108721WT (WT)	21.0-23.0	12,056	-	-	7,658	-	-	23	-	-	-
	SP108723DH	22.7-23.7	11,807	-	-	4,611	-	NA	-	-	-	-
	SP108724DH	23.7-25.7	10,210	-	-	4,461	-	NA	-	-	-	-
SP11-87	SP11870008	0.0-8.8	-	-	-	6,246	-	-	-	-	-	-
	SP118708DH	8.8-11.3	-	-	-	5,132	-	-	-	-	-	-
	SP118711DH	11.5-14.0	-	-	-	3,062	-	-	-	-	-	-
	SP118714DH	14.0-15.1	-	-	-	5,716	-	-	-	-	-	-
	SP118716DH	16.5-17.8	-	-	-	2,873	-	-	-	17,914	-	-
	SP118719DH	19.0-21.5	-	-	-	7,883*	-	-	-	-	-	-
	SP118721DH	21.5-24.0	-	-	-	-	-	-	-	-	-	-
	SP118724DH	24.0-26.5	-	-	-	-	-	-	-	-	-	-
	SP118726DH	26.5-29.0	-	-	-	4,192	-	-	17	-	-	-
	SP118729DH	29.0-31.5	9,892	-	-	6,571	-	612*	32	18,835	-	-
SP12-87	SP12870009	0.0-9.0	-	-	-	-	-	-	-	-	-	-
	SP12870916	9.0-16.5	-	-	-	3,025	-	-	-	-	-	-
	SP128716DH	16.5-19.0	17,771	-	143	17,225*	-	40*	19	12,600	-	-
	SP128719DH	19.0-21.5	16,308	-	171	7,228	-	36	20	17,912	-	-
	SP128721DH	21.5-24.0	-	-	-	1,974	-	-	-	-	-	3,000
	SP128724DH	24.0-25.2	-	-	-	-	-	-	-	-	-	-
	SP128726DH	26.5-29.0	-	-	-	4,336	-	-	15	-	-	-
	SP128729DH	29.0-31.5	-	-	-	2,514	-	-	14	-	-	-
	SP128731DH	31.5-32.2	11,755	-	-	7,658*	-	15	26	-	-	-
	SP128734DH	34.0-34.5	11,099	-	-	9,273*	-	-	23	16,856	-	-
	SP128739DH	39.0-/1.5	-	-	-	3,293*	-	-	15	-	-	-
	SP128741DH	41.5-44.0	11,221	-	-	-	-	-	-	-	-	-

After: Rockwell, 1988b Vol. II P. 4-18

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Mg (2500)	Mn (337)	Ni (20u)**	V (38)	Zn (49)	Be (3.4U)	Cd (3.4U)	Sb (41U)	Tl (6.8U)
SP10-87	SP108700DH	0.0-1.8	-	-	-	-	-	-	4.04	-	-
	SP108702DH	2.0-3.9	2,670	-	-	-	53	4.44	-	-	-
	SP108704BR	4.0-5.0	-	509	-	-	68	-	-	-	-
	SP108705DH	5.0-7.0	-	-	-	-	66	-	-	-	-
	SP108707DH	7.0-9.0	-	-	-	-	-	-	-	-	-
	SP108709DH	9.0-11.0	NA	NA	NA	NA	NA	-	-	-	-
	SP108711DH	11.0-13.0	-	-	-	-	-	-	-	-	-
	SP108713DH	13.0-14.9	-	-	-	-	-	-	-	-	-
	SP108715DH	15.0-16.9	-	-	-	-	-	-	-	-	-
	SP108717DH	17.0-19.0	-	426	-	-	-	3.66	-	-	-
	SP1087017D	17.0-19.0	-	-	-	-	61	-	-	-	-
	SP108719DH	19.0-21.0	2,685	-	-	-	52	-	100.66*	-	-
	SP108721WT (WT)	21.0-23.0	-	-	-	-	51	-	-	-	-
	SP108723DH	22.7-23.7	-	-	-	-	-	-	-	-	-
	SP108724DH	23.7-25.7	-	-	-	-	56	-	-	-	-
SP11-87	SP11870008	0.0-8.8	-	-	-	-	-	-	-	-	-
	SP118708DH	8.8-11.3	-	-	-	-	-	-	3.42	-	-
	SP118711DH	11.5-14.0	-	-	-	-	-	-	-	-	-
	SP118714DH	14.0-15.1	-	-	29	-	50	-	-	-	-
	SP118716DH	16.5-17.8	-	-	-	-	-	-	-	-	-
	SP118719DH	19.0-21.5	-	-	-	-	-	-	-	-	-
	SP118721DH	21.5-24.0	-	-	-	-	-	-	-	-	-
	SP118724DH	24.0-26.5	-	-	-	-	-	-	-	-	-
	SP118726DH	26.5-29.0	-	-	-	-	49	-	-	-	-
	SP118729DH	29.0-31.5	3,330	-	366*	-	84	-	-	-	-
SP12-87	SP12870009	0.0-9.0	-	-	-	-	-	-	-	-	-
	SP12870916	9.0-16.5	-	-	-	-	-	-	3.50	-	-
	SP128716DH	16.5-19.0	2,809	-	-	-	50	-	-	-	-
	SP128719DH	19.0-21.5	2,803	-	-	46	66	-	-	-	-
	SP128721DH	21.5-24.0	-	-	-	-	-	-	-	-	-
	SP128724DH	24.0-25.2	-	-	-	-	-	-	-	-	-
	SP128726DH	26.5-29.0	-	-	-	-	-	-	-	-	-
	SP128729DH	29.0-31.5	-	-	-	-	-	-	-	-	-
	SP128731DH	31.5-32.2	-	-	-	-	91	-	-	-	-
	SP128734DH	34.0-34.5	2,784	-	32	-	116	-	-	-	-
	SP128739DH	39.0-41.5	-	-	-	-	69	-	-	-	-
	SP128741DH	41.5-44.0	-	-	-	-	66	-	-	-	-

After: Rockwell, 1988b Vol. II P. 4-19

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Al (9140)	As (10)	Ba (135u)	Ca (2500u)	Co (25)	Cr (13)	Cu (13u)	Fe (12,400)	Hg (0.1U)	K (2500)
SP13-87	SP138700UC	0.0-1.5	13,770	-	161	6,215	-	-	19	14,828	-	-
	SP138701CT	1.5-3.5	10,070	-	-	5,617	-	-	21	-	-	-
	SP138703BR	3.5-6.5	9,162	-	-	4,819	-	-	28	-	-	-
	SP138706DH	6.5-9.0	-	-	-	3,778	-	-	16	14,200	-	-
	SP138760UP	6.5-9.0	-	-	-	-	-	-	-	-	-	-
	SP138709DH	9.0-11.5	-	-	-	-	-	-	-	-	-	-
	SP138711DH	11.5-14.0	-	-	-	-	-	-	-	-	-	-
SP14-87	SP148700UC	0.0-0.4	NA	NA	NA	-	-	NA	NA	NA	-	NA
	SP148702CT	2.0-4.0	10,810	-	-	5,515	-	-	19	NA	-	-
	SP148704BR	4.0-7.0	-	-	-	4,869	-	17	21	-	-	-
SP15-87	SP158702DH	2.0-2.8	12,674	-	182	6,420	-	24	18	26,993	-	-
	SP158704DH	4.0-4.4	12,020	-	140	7,205	-	18	19	20,517	-	-
	SP158708DH	8.0-10.0	10,159	-	-	2,639	-	-	-	14,666	-	-
	SP1587008D	8.0-10.0	20,546	-	242	4,789	-	21	23	29,505	-	-
	SP158710DH	10.0-12.0	11,604	-	179	3,134	-	503*	29	23,469	-	-
	SP158712WT (WT)	12.0-14.5	-	-	-	2,654	-	-	-	-	-	-
	SP158714CT	14.5-17.0	11,560	-	144	4,710	-	-	23	21,362	-	-
	SP158716BR	17.0-19.0	11,327	-	261	4,728	-	-	20	-	-	-
56-87/ SP16-87	SP168702FS	0.0-2.0	12,751	NA	-	-	-	21	17	16,363	-	NA
	SP168708UC	6.0-8.0	9,726	NA	-	63,857*	-	16	-	-	-	NA
	SP168710CT	10.0-11.2	9,673	NA	-	85,844*	-	18	-	-	-	NA
	SP168711BR	11.2-13.4	-	NA	345	16,274*	-	17	22	-	-	NA
18-86	C188608860	6.5-10.3	25,000	-	210	8,000*	-	24	-	22,000	-	3,270
	C188608861	13.0-14.0	11,700	-	-	7,160	-	-	-	-	-	-
	C188608862	35.0-38.0	9,440	-	-	19,200*	34	-	-	-	0.14	-

After: Rockwell, 1988b Vol. II P. 4-20

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Mg (2500)	Mn (337)	Ni (20u)**	V (38)	Zn (49)	Be (3.4U)	Cd (3.4U)	Sb (41U)	Tl (6.8U)
SP13-87	SP138700UC	0.0-1.5	-	-	-	-	62	-	-	-	-
	SP138701CT	1.5-3.5	-	-	-	-	-	-	-	-	-
	SP138703BR	3.5-6.5	-	-	-	-	63	-	-	-	-
	SP138706DH	6.5-9.0	-	-	-	-	126	-	-	-	-
	SP13876DUP	6.5-9.0	-	-	-	-	-	-	-	-	-
	SP138709DH	9.0-11.5	-	-	-	-	-	-	-	-	-
	SP138711DH	11.5-14.0	-	-	-	-	-	-	-	-	-
SP14-87	SP148700UC	0.0-0.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP148702CT	2.0-4.0	-	-	-	-	68	-	-	-	-
	SP148704BR	4.0-7.0	-	-	-	-	-	-	-	-	-
SP15-87	SP158702DH	2.0-2.8	-	512	32	-	62	-	-	-	-
	SP158704DH	4.0-4.4	2,550	-	41	-	67	NA	NA	NA	NA
	SP158708DH	8.0-10.0	-	-	33	-	55	-	-	-	-
	SP1587008D	8.0-10.0	3,265	-	41	-	-	-	-	-	-
	SP158710DH	10.0-12.0	-	502	543*	-	-	-	-	-	-
	SP158712WT (WT)	12.0-14.5	-	-	-	-	-	-	-	-	-
	SP158714CT	14.5-17.0	2,867	-	-	-	75	-	-	-	-
	SP158716BR	17.0-19.0	2,801	-	-	-	85	-	-	-	-
56-87/ SP16-87	SP168702FS	0.0-2.0	-	-	-	-	103	103.13*	64.67*	16,362.67*	12,750.58*
	SP168708UC	6.0-8.0	-	-	-	-	-	24.29*	43.96*	8,943.78*	9,725.90*
	SP168710CT	10.0-11.2	-	-	-	-	-	24.15*	83.15*	10,297.33*	9,673.45*
	SP168711BR	11.2-13.4	-	1,258*	-	-	51	50.66*	345.06*	10,681.13*	6,670.45*
18-86	C188608860	6.5-10.3	6,730		-	-	70	-	-	-	-
	C188608861	13.0-14.0	2,650		-	-	62	-	-	-	-
	C188608862	35.0-38.0	-		-	-	93	-	-	-	-

After: Rockwell, 1988b Vol. II P. 4-21

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Al (9140)	As (10)	Ba (135u)	Ca (2500u)	Co (25)	Cr (13)	Cu (13u)	Fe (12,400)	Hg (0.1U)	K (2500)
20-86	C208609860	2.0-4.0	44,400*	-	160	4,050	-	33	-	34,700	-	8,020
	C208609861	13.0-14.70	11,900	-	-	6,500	-	-	-	13,000	-	-
	C208609862	20.4-22.0	15,000	-	-	9,160*	-	-	15	-	0.20	-
22-86	C228609860	FILL	11,900	-	-	6,500	-	-	-	13,000	-	-
	C228609861	CONTACT	-	-	-	-	-	-	-	-	-	-
	C228609862	BEDROCK	15,000	-	-	9,160*	-	-	15	-	0.20	-
25-86	C258608860	FILL	15,000	-	-	254,000*	-	-	-	-	0.16	-
	C258608861	12.5-14.5	16,200	-	550*	3,690	-	-	-	14,700	-	-
	C258608862	20.5-22.5	10,300	-	-	3,400	-	-	-	-	-	-
27-86	C278609860	5.7-8.0	10,600	-	-	10,400*	-	-	14	-	0.98*	-
	C278609861	12.0-13.8	14,400	-	-	5,750	-	-	17	-	-	-
	C278609862	20.5-22.5	11,500	-	-	5,280	-	-	-	-	2.8*	-

NOTES:
(1) "-" Value below upper background limit.
(2) Values in parentheses are the upper range of background values described in 881 Hillside RI Report, Rockwell International, 1988. "U" indicates detection limit.
(3) Values are rounded to the nearest integer. Lab reported values are listed in Appendix D.
(4) * Indicates value greater than 3 times the upper background value.
(5) (WT) indicates water table sample.
(6) "NA" indicates sample not analyzed.
(7) ** Nickel background is 20 U. The table does not include Solar Pond nickel values below detection limits of 27U.

After: Rockwell, 1988b Vol. II P. 4-22

Table 2-14
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Mg (2500)	Mn (337)	Ni (20u)**	V (38)	Zn (49)	Be (3.4U)	Cd (3.4U)	Sb (41U)	Tl (6.8U)
20-86	C208609860	2.0-4.0	4,380		-	53	65	-	-	-	-
	C208609861	13.0-14.70	2,860		41	-	59	-	-	-	-
	C208609862	20.4-22.0	2,840		-	-	81	-	-	-	-
22-86	C228609860	FILL	2,860		41	-	59	-	-	-	-
	C228609861	CONTACT	-		-	-	-	-	-	-	-
	C228609862	BEDROCK	2,840		-	-	-	-	-	-	-
25-86	C258608860	FILL	8,810		-	-	81	-	-	-	-
	C258608861	12.5-14.5	4,920		-	40	94	-	-	-	-
	C258608862	20.5-22.5	-		-	-	-	-	-	-	-
27-86	C278609860	5.7-8.0	-		42	-	51	-	-	-	-
	C278609861	12.0-13.8	3,700		-	-	84	-	-	-	-
	C278609862	20:5-22.5	-		-	-	-	-	-	-	-

NOTES:
(1) "-" Value below upper background limit.
(2) Values in parentheses are the upper range of background values described in 881 Hillside RI Report, Rockwell International, 1988. "U" indicates detection limit.
(3) Values are rounded to the nearest integer. Lab reported values are listed in Appendix D.
(4) * Indicates value greater than 3 times the upper background value.
(5) (WT) indicates water table sample.
(6) "NA" indicates sample not analyzed.
(7) ** Nickel background is 20 U. The table does not include Solar Pond nickel values below detection limits of 27U.

After: Rockwell, 1988b Vol. II P. 4-23

Table 2-15
METAL CONCENTRATIONS IN SOILS GREATER THAN THREE TIMES BACKGROUND (mg/kg)

Sample No.	Al (9140)	As (10)	Be (3.4u)	Cd (3.4u)	Cr (13)	Cu (13u)	Mn (337)	Ni (20u)	Sb (41u)	Tl (6.8u)
SP018700FS	30,899	--	--	--	--	--	--	--	--	--
SP048702DH	--	--	--	51	--	--	--	--	--	--
SP048704DH	--	--	--	71	--	--	--	--	--	--
SP04870040	--	--	--	119	--	--	--	--	--	--
SP058702DH	--	--	--	16	--	58	--	--	--	--
SP058704DH	--	--	--	10	--	--	--	--	--	--
SP058707DH	--	--	--	84	--	--	--	--	--	--
SP058710DH	--	--	--	22	780	--	--	474	--	--
SP058712DH	--	--	--	20	132	--	--	--	--	--
SP068702FS	--	35	--	--	--	--	--	--	--	--
SP068724DH	--	--	--	--	40	--	--	--	--	--
SP078700DH	--	--	--	--	--	44	--	--	--	--
SP078708FS	30,265	--	--	--	--	--	--	--	--	--
SP078716DH	--	--	--	--	586	--	--	514	--	--
SP078718WT	--	--	--	--	393	--	--	313	--	--
SP078721CT	--	--	--	--	92	--	--	94	--	--
SP078723BR	--	64	--	--	--	--	--	--	--	--
SP078726DH	--	55	--	--	--	--	--	--	--	--
SP108719DH	--	--	--	101	--	--	--	--	--	--
SP118729DH	--	--	--	--	612	--	--	366	--	--
SP128716DH	--	--	--	--	40	--	--	--	--	--
SP158710DH	--	--	--	--	503	--	--	543	--	--
SP168702FS	--	--	103	65	--	--	--	--	16,363	12,751
SP168708UC	--	--	24	44	--	--	--	--	8,944	9,726
SP168710CT	--	--	24	83	--	--	--	--	10,297	9,673
SP168711BR	--	--	51	345	--	--	1,258	--	10,681	6,670

NOTES: (1) "--" Value below three times the upper background limit.
(2) Values in parentheses are the upper range of background values described in 881 Hillside RI Report, Rockwell International, 1988. "U" indicates detection limit.
(3) Values are rounded to the nearest integer.

After: Rockwell, 1988b Vol. II P. 4-24

Table 2-16
RADIONUCLIDE CONCENTRATIONS IN SOILS ABOVE BACKGROUND LEVELS (pCi/g)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	$U^{233+234}$	U^{238}	$Pu^{239+240}$	Am^{241}
Background Maximum			[1.4(0.2)]	[1.2(0.2)]	[0.1(0.20)]	[0.28(0.16)]
SP01-87	SP018700FS	0.0-1.2	4.0(0.6)	1.9(0.4)	18(1)	2.2(0.2)
	SP018704DH	4.0-5.0	-	2.1(0.5)	-	-
	SP018705DH	5.0-6.3	-	2.8(0.5)	-	-
SP04-87	SP048702DH	2.0-3.7	-	-	1.9(0.3)	-
SP05-87	SP0587160H	15.3-17.3	-	-	0.5(0.16)	1.2(0.2)
SP06-87	SP068702FS	2.0-3.7	-	-	0.52(0.16)	-
	SP0687180H	18.0-20.5	-	1.7(0.2)	-	-
SP07-87	SP078700DH	0.0-1.8	-	-	2.2(0.3)	-
SP10-87	SP108700DH	0.0-1.8	-	-	3.5(0.3)	-
	SP108702DH	2.0-3.9	3.7(0.4)	-	-	-
SP11-87	SP118716DH	16.5-17.8	-	1.7(0.2)	-	-
SP16-87	SP168702FS	0.0-2.0	-	-	9.0(0.6)	0.96(0.26)
20-86	C208609860	2.0-4.0	-	2.7(0.3)	-	-
	C208609862	20.4-28.0	-	2.1(0.4)	-	-
22-86	C228609861	Contact	-	1.8(0.4)	-	-
25-86	C258608860		-	-	0.42(0.05)	-

NOTE: (1) Values in parentheses indicate counting errors.

(2) "-" Indicates value below maximum background value or counting error is greater than its associated value.

(3) Maximum background is the upper range of background values described in the 881 Hillside RI Report, Rockwell International, 1988.

After: Rockwell, 1988b Vol. II P. 4-28

Table 2-17
COMPARISON OF 1986 AND 1989 BACKGROUND VALUES[a]

Metals	1986 Background Values (mg/kg)	1989 Background Values (mg/kg)	Ratio 1986 Value/ 1989 Value
Aluminum	9,140	40,800	0.22
Antimony	41U	NA	NA
Arsenic	10	41.7	0.24
Barium	135U	209	0.65
Beryllium	3.4U	19	0.18
Calcium	2,500U	157,000	0.02
Cadmium	3.4U	3.2	1.10
Chromium(TOT)	13	69.6	0.19
Cobalt	25	18.2	1.40
Copper	12U	31.6	0.38
Iron	12,400	33,700	0.37
Lead	48	21.9	2.20
Magnesium	2,500U	5,570	0.44
Manganese	337	656	0.51
Mercury	0.1U	0.58	0.17
Nickel	20U	54.2	0.37
Potassium	2,500U	4,020	0.62
Selenium	3.4U	NA	NA
Silver	5U	40.9	0.12
Sodium	2,500U	NA	NA
Thallium	6.8U	NA	NA
Tin	41U	NA	NA
Vanadium	38	70	0.54
Zinc	49	77.6	0.63

Table 2-17
COMPARISON OF 1986 AND 1989 BACKGROUND VALUES[a]
(continued)

Radionuclides	1986 Background Concentration (pCi/g)	1989 Background Concentration (pCi/g)	Ration 1986 Value/ 1989 Value
Plutonium	0.1	0.03	3.3
Americium	0.28	0.01	28.0
Uranium 233+234	1.4	3.4	0.41
Uranium 238	1.2	3.2	0.38
Tritium (pCi/ml)	NA	0.44	NA

[a]Numerical values followed by a "U" represent the method detection limit for the specific element. The associated numerical value was used for comparison.

Note: NA represents that data was unavailable for specific element.

Table 2-18
SOIL SAMPLING PARAMETERS

Metals

Hazardous Substance List--Metals
Beryllium
Lithium
Strontium

Organics

Hazardous Substance List--Volatiles
Hazardous Substance List--Semivolatiles[a]
Oil and Grease[a]

Radionuclides

Gross Alpha
Gross Beta
Uranium 233, 234, and 238
Americium 241
Plutonium 239, 240
Strontium 90
Tritium[a]

Other

Pesticides[a]
PCBs[a]
Cyanide
Sulfide[b]
Nitrates, Nitrite, Nitrogen
Percent Solids
pH

[a]Analyses not requested for 1987 borehole soil samples.
[b]Analyses not requested for 1986 core samples.

Notes: 1. Analytical methods are presented in the IGMP Work Plan for Rocky Flats Plant (DOE), 1986a.

After: Rockwell, 1988b Vol. II P. 4-12

Table 2-19
CONCENTRATIONS OF NITRATE IN SOIL SAMPLES (mg/kg)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Nitrate as Nitrogen
SP01-87	SP018700FS	0.0-1.2	25.0
	SP018704DH	4.0-5.0	96.0
	SP018705DH	5.0-6.3	131.0
	SP018711DH	10.5-12.2	4.0
	SP018713DH	12.7-14.9	8.0
	SP018716BR (WT)	15.2-16.7	2.0U
	SP018721DH	20.2-22.3	2.0U
	SP018723DH	22.7-24.1	8.0
SP02-87	SP02870008	0.0-10.1	9.0
	SP028708UC	7.1-10.1	12.0
	SP028711CT	10.1-12.6	3.0
	SP028713BR	12.6-15.1	2.0U
SP03-87	SP038702DH	2.0-3.5	NA
	SP038703FS	4.0-4.6	NA
	SP038711DH	10.3-11.6	200.0
	SP038713CT	12.8-14.4	186.0
	SP038716BR	15.2-16.9	260.0
SP04-87	SP048702DH	2.0-3.7	2.0U
	SP048704DH	4.0-5.8	5.0
	SP0487004D	4.0-5.8	4.0
	SP048707DH	7.0-8.7	5.0
	SP048710DH	9.5-10.1	NA
	SP048712DH (WT)	12.6-14.5	361.0
	SP048715FS	14.5-17.0	142.0
	SP048717DH	17.0-19.5	14.0
	SP048720DH	19.5-22.0	101.0
	SP048722DH	22.0-24.0	79.0
	SP048725DH	24.5-27.0	13.0
	SP048727DH	27.0-29.5	2.0U
	SP048730DH	29.5-32.0	2.0
	SP048732DH	32.0-34.0	25.0
SP05-87	SP058700DH	0.0-0.4	NA
	SP058702DH	2.0-3.3	8.0
	SP058704DH	4.0-5.6	2.0U
	SP058707DH	7.0-8.3	9.0
	SP058710DH	9.5-10.1	345.0
	SP058712DH (WT)	12.8-14.4	705.0
	SP058716DH	15.3-17.3	1480.0
SP06-87	SP068702FS	2.0-3.7	307.0
	SP068708DH	8.0-10.4	22.0
	SP068711DH	10.5-12.4	2.0U
	SP068713DH	13.0-14.3	2.0U
	SP068716DH	15.5-17.7	2.0U
	SP068718DH	18.0-20.5	2.0U
	SP068721DH	20.5-23.0	2.0U
	SP068724DH	23.2-25.7	2.0U
	SP068726DH	25.7-28.2	4.0

After: Rockwell, 1988b Vol. II P. 4-30

Table 2-19
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Nitrate as Nitrogen
SP07-87	SP078700DH	0.0-1.8	2.0U
	SP078702DH	2.0-3.8	2.0U
	SP078708FS	8.0-10.3	2.0
	SP078711DH	10.5-12.2	3.0
	SP078713DH	13.0-14.8	2.0U
	SP078716DH	15.5-16.7	150.0
	SP078718WT (WT)	18.0-19.3	480.0
	SP078721CT	20.5-23.0	656.0
	SP078723BR	23.0-26.0	58.0
	SP078726DH	26.0-28.5	2.0
39-87/ SP08-87	SP088703UC	3.5-6.5	511.0
	SP088706CT	6.5-8.5	396.0
	SP088709BR	9.0-11.5	638.0
SP09-87	SP098703UC	3.0-5.1	329.0
	SP098706CT	6.0-8.5	87.0
	SP098708BR	8.5-11.0	242.0
SP10-87	SP108700DH	0.0-1.8	4.0
	SP108702DH	2.0-3.9	15.0
	SP108704BR	4.0-5.0	10.0
	SP108705DH	5.0-7.0	11.0
	SP108707DH	7.0-9.0	10.0
	SP108709DH	9.0-11.0	14.0
	SP108711DH	11.0-13.0	12.0
	SP108713DH	13.0-14.9	14.0
	SP108715DH	15.0-16.9	26.0
	SP108717DH	17.0-19.0	16.0
	SP1087017D	17.0-19.0	23.0
	SP108719DH	19.0-21.0	12.0
	SP108721WT (WT)	21.0-23.0	11.0
	SP108723DH	22.7-23.7	10.0
	SP108724DH	23.7-25.7	13.0
SP11-87	SP11870008	0.0-8.8	9.0
	SP118708DH	8.8-11.3	2.0U
	SP118711DH	11.5-14.0	2.0U
	SP118714DH	14.0-15.1	2.0U
	SP118716DH	16.5-17.8	3.0
	SP118719DH	19.0-21.5	10.0
	SP118721DH	21.5-24.0	11.0
	SP118724DH	24.0-26.5	10.0
	SP118726DH	26.5-29.0	12.0
	SP118729DH	29.0-31.5	2.0U

After: Rockwell, 1988b Vol. II P. 4-31

Table 2-19
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	Nitrate as Nitrogen
SP12-87	SP12870009	0.0-9.0	3.0
	SP12870916	9.0-16.5	3.0
	SP128716DH	16.5-19.0	3.0
	SP128719DH	19.0-21.5	2.0U
	SP128721DH	21.5-24.0	4.0
	SP128724DH	24.0-25.2	8.0
	SP128726DH	26.5-29.0	35.0
	SP128729DH	29.0-31.5	11.0
	SP128731DH	31.5-32.2	3.0
	SP128734DH	34.0-34.5	21.0
	SP128739DH	39.0-41.5	2.0U
	SP128741DH	41.5-44.0	3.0
SP13-87	SP138700UC	0.0-1.5	2.0U
	SP138701CT	1.5-3.5	2.0U
	SP138703BR	3.5-6.5	4.0
	SP138706DH	6.5-9.0	2.0U
	SP13876DUP	6.5-9.0	2.0U
	SP138709DH	9.0-11.5	21.0
	SP138711DH	11.5-14.0	2.0U
SP14-87	SP148700UC	0.0-0.4	NA
	SP148702CT	2.0-4.0	251.0
	SP148704BR	4.0-7.0	220.0
SP15-87	SP158702DH	2.0-2.8	20.0
	SP158704DH	4.0-4.4	NA
	SP158708DH	8.0-10.0	2.0
	SP1587008D	8.0-10.0	3.0
	SP158710DH	10.0-12.0	2.0U
	SP158712WT (WT)	12.0-14.5	2.0U
	SP158714CT	14.5-17.0	4.0
	SP158716BR	17.0-19.0	2.0U
56-87/ SP16-87	SP168702FS	0.0-2.0	11.0
	SP168708UC	6.0-8.0	12.0
	SP168710CT	10.0-11.2	3.0
	SP168711BR	11.2-13.4	2.0U

NOTES: (1) "U" Indicates detection limit.

(2) "E" with no result: Indicates that the sample contained a substance that interfered with the titration, masking the color change of the indicator, making the end point impossible to determine.

(3) "E" with a result: Indicates that the end point color change was a dark salmon color instead of peach, indicating possible interference. hundredth.

(4) "NA" Indicates that sample was not analyzed.

After: Rockwell, 1988b Vol. II P. 4-32

Table 2-[illegible]
VOLATILE ORGANIC CONCENTRATIONS DETECTED IN SOIL AND CORE SAMPLES (ug/kg)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	MeCl	Acetone	1,1-DCA	$CHCl_3$	MEK	1,1,1-TCA	TCE	Toluene	Total Xylenes
SP01-87	SP018700FS	0.0-1.2	-	-	-	-	-	-	-	-	-
	SP018704DH	4.0-5.0	-	-	-	6J	-	-	-	-	-
	SP018705DH	5.0-6.3	-	-	-	-	-	-	-	-	-
	SP018711DH	10.5-12.2	-	-	-	-	-	-	-	-	-
	SP018713DH	12.7-14.9	-	-	-	6J	-	-	-	-	-
	SP018716BR (WT)	15.2-16.7	-	-	-	-	-	-	-	-	-
	SP018721DH	20.2-22.3	-	-	-	-	-	-	-	-	-
	SP018723DH	22.7-24.1	-	-	-	-	-	-	-	-	-
SP02-87	SP02870008	0.0-10.1	-	-	-	-	-	-	-	-	-
	SP028708UC	7.1-10.1	-	-	-	-	-	-	-	-	-
	SP028711CT	10.1-12.6	-	-	-	10J	-	-	-	-	-
	SP028713BR	12.6-15.1	-	-	-	6J	-	-	-	-	-
SP03-87	SP038702DH	2.0-3.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP038703FS	4.0-4.6	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP038711DH	10.3-11.6	-	-	-	-	-	-	-	-	-
	SP038713CT	12.8-14.4	-	-	-	-	-	-	-	-	-
	SP038716BR	15.2-16.9	-	-	-	5J	-	-	-	-	-
SP04-87	SP048702DH	2.0-3.7	-	-	-	-	-	-	10J	-	-
	SP048704DH	4.0-5.8	-	-	-	-	-	-	-	-	-
	SP0487004D	4.0-5.8	-	-	-	-	-	-	-	-	-
	SP048707DH	7.0-8.7	-	-	-	-	-	-	-	-	-
	SP048710DH	9.5-10.1	-	-	-	11J	-	-	-	-	-
	SP048712DH (WT)	12.6-14.5	-	-	-	10J	-	-	-	-	-
	SP048715FS	14.5-17.0	-	-	-	-	-	-	-	-	-
	SP048717DH	17.0-19.5	-	-	-	-	-	-	-	-	-
	SP048720DH	19.5-22.0	-	-	-	-	-	-	-	-	-
	SP048722DH	22.0-24.0	-	-	-	-	-	-	-	-	-
	SP048725DH	24.5-27.0	-	-	-	-	-	-	-	-	-
	SP048727DH	27.0-29.5	-	-	-	-	-	-	-	-	-
	SP048730DH	29.5-32.0	-	-	-	-	-	-	-	-	-
	SP048732DH	32.0-34.0	-	-	-	-	-	-	-	-	-
SP05-87	SP058700DH	0.0-0.4	-	-	-	-	-	-	-	-	-
	SP058702DH	2.0-3.3	-	-	-	-	-	-	-	-	-
	SP058704DH	4.0-5.6	-	-	-	-	-	-	-	-	-
	SP058707DH	7.0-8.3	-	-	-	-	-	-	-	-	-
	SP058710DH	9.5-10.1	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP058712DH (WT)	12.8-14.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP058716DH	15.3-17.3	NA	NA	NA	NA	NA	NA	NA	NA	NA

After: Rockwell, 1988b Vol. II P. 4-34

Table 2-20
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	MeCl	Acetone	1,1-DCA	$CHCl_3$	MEK	1,1,1-TCA	TCE	Toluene	Total Xylenes
SP06-87	SP068702FS	2.0-3.7	6.40J	-	-	-	-	-	-	-	-
	SP068708DH	8.0-10.4	52.0	-	-	-	-	-	-	-	-
	SP068711DH	10.5-12.4	-	-	-	-	-	-	-	-	-
	SP068713DH	13.0-14.3	-	-	-	-	-	-	-	-	-
	SP068716DH	15.5-17.7	-	-	-	-	-	-	-	-	-
	SP068718DH	18.0-20.5	6.80J	-	-	-	-	-	-	-	-
	SP068721DH	20.5-23.0	-	-	-	-	-	-	-	-	-
	SP068724DH	23.2-25.7	-	-	-	-	-	-	-	-	-
	SP068726DH	25.7-28.2	-	-	-	-	-	-	-	-	-
SP07-87	SP078700DH	0.0-1.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078702DH	2.0-3.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078708FS	8.0-10.3	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078711DH	10.5-12.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078713DH	13.0-14.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078716DH	15.5-16.7	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078718WT (WT)	18.0-19.3	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078721CT	20.5-23.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078723BR	23.0-26.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP078726DH	26.0-28.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
39-87/ SP08-87	SP088703UC	3.5-6.5	-	-	-	-	-	-	-	-	-
	SP088706CT	6.5-8.5	-	-	-	-	-	-	-	-	-
	SP088709BR	9.0-11.5	-	-	-	-	-	-	-	-	-
SP09-87	SP098703UC	3.0-5.1	-	-	-	10J	-	-	-	-	-
	SP098706CT	6.0-8.5	-	-	-	-	-	-	-	-	-
	SP098708BR	8.5-11.0	-	-	-	-	-	-	-	-	-
SP10-87	SP108700DH	0.0-1.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108702DH	2.0-3.9	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108704BR	4.0-5.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108705DH	5.0-7.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108707DH	7.0-9.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108709DH	9.0-11.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108711DH	11.0-13.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108713DH	13.0-14.9	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108715DH	15.0-16.9	NA	NA	NA	NA	NA	NA	NA	NA	NA

After: Rockwell, 1988b Vol. II P. 4-35

Table 2-20
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	MeCl	Acetone	1,1-DCA	$CHCl_3$	MEK	1,1,1-TCA	TCE	Toluene	Total Xylenes
SP10-87	SP108717DH	17.0-19.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP1087017D	17.0-19.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108719DH	19.0-21.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108721WT (WT)	21.0-23.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108723DH	22.7-23.7	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP108724DH	23.7-25.7	NA	NA	NA	NA	NA	NA	NA	NA	NA
SP11-87	SP11870008	0.0-8.8	-	-	-	-	-	-	-	-	-
	SP118708DH	8.8-11.3	-	-	-	-	-	-	-	-	-
	SP118711DH	11.5-14.0	-	-	-	-	-	-	-	-	-
	SP118714DH	14.0-15.1	-	-	-	-	29.30	-	-	-	-
	SP118716DH	16.5-17.8	-	-	-	-	-	-	-	-	-
	SP118719DH	19.0-21.5	-	-	-	-	-	-	-	-	-
	SP118721DH	21.5-24.0	-	-	-	-	-	-	-	-	-
	SP118724DH	24.0-26.5	-	-	-	-	-	-	-	-	-
	SP118726DH	26.5-29.0	-	-	-	-	-	-	-	-	-
	SP118729DH	29.0-31.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
SP12-87	SP12870009	0.0-9.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP12870916	9.0-16.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128716DH	16.5-19.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128719DH	19.0-21.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128721DH	21.5-24.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128724DH	24.0-25.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128726DH	26.5-29.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128729DH	29.0-31.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128731DH	31.5-32.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128734DH	34.0-34.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128739DH	39.0-41.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP128741DH	41.5-44.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
SP13-87	SP138700UC	0.0-1.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP138701CT	1.5-3.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP138703BR	3.5-6.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP138706DH	6.5-9.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP13876DUP	6.5-9.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP138709DH	9.0-11.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP138711DH	11.5-14.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
SP14-87	SP148700UC	0.0-0.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP148702CT	2.0-4.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP148704BR	4.0-7.0	NA	NA	NA	NA	NA	NA	NA	NA	NA

After: Rockwell, 1988b Vol. II P. 4-36

Table 2-20
(continued)

Well No. and/or Borehole No.	Sample No.	Interval (ft)	MeCl	Acetone	1,1-DCA	$CHCl_3$	MEK	1,1,1-TCA	TCE	Toluene	Total Xylenes
SP15-87	SP158702DH	2.0-2.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP158704DH	4.0-4.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP158708DH	8.0-10.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP1587008D	8.0-10.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP158710DH	10.0-12.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP158712WT (WT)	12.0-14.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP158714CT	14.5-17.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP158716BR	17.0-19.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
56-87/ SP16-87	SP168702FS	0.0-2.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP168708UC	6.0-8.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP168710CT	10.0-11.2	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SP168711BR	11.2-13.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
18-86	C188608860	6.5-10.3	24	72	-	-	-	-	-	-	-
	C188608861	13.0-14.0	10	110	-	-	-	-	-	-	-
	C188608862	35.0-38.0	10	165B	-	-	-	2J	7J	2BJ	-
20-86	C208609860	2.0-4.0	2J	35B	4J	-	-	-	-	1J	-
	C208609861	13.0-14.70	2J	44B	6	-	13B	-	-	-	-
	C208609862	20.4-22.0	2J	45B	2J	-	-	-	-	-	-
22-86	C228609860	FILL	2J	31B	3J	-	-	21B	-	1J	4J
	C228609861	CONTACT	7J	39B	25	-	-	3J	-	2J	4J
	C228609862	BEDROCK	8J	124B	43	-	-	5J	-	2J	5J
25-86	C258608860	FILL	9	46B	42	21	-	-	-	8B	11
	C258608861	12.5-14.5	6J	89BJ	16	-	-	2J	-	1BJ	-
	C258608862	20.5-22.5	5J	30BJ	13	-	-	-	-	1BJ	-
27-86	C278609860	5.7-8.0	2J	49BJ	3J	-	-	-	-	-	-
	C278609861	12.0-13.8	12	41B	49	-	12	6J	-	2BJ	-
	C278609862	20.5-22.5	10	52B	35	-	-	4J	-	2BJ	2J

NOTES: (1) Abbreviations: MeCl = Methylene Chloride; 1,1-DCA = 1,1-Dichloroethane; $CHCl_3$ = Chloroform; MEK = 2-Butanone; 1,1,1-TCA = 1,1,1-Trichloroethane; TCE = Trichloroethene.

(2) "J" indicates that value is estimated below detection limit.
"-" indicates compound concentration below detection limit.

(3) "NA" indicates sample holding time exceeded; therefore, sample not analyzed.

(4) "B" indicates that the compound was present in the laboratory blank.

After: Rockwell, 1988b Vol. II P. 4-37

Table 3-1
PHASE I RFI/RI DATA NEEDS AND SAMPLING OBJECTIVES

DATA NEED	SAMPLING OBJECTIVE
POND LIQUIDS AND SEDIMENTS	
• Chemical and radiological characteristics	Collect Solar Evaporation Ponds liquid and sediment samples for analysis
• Sediment volume estimate	Measure sediment thickness Determine area of ponds
POND LINER AND BASE COURSE	
• Chemical and radiological characteristics	Collect Solar Evaporation Ponds liner and base course samples for analysis
• Liner and base course volume estimate	Measure liner and base course thickness Determine pond area
SOIL/VADOSE ZONE	
• Determine lateral extent of surficial soil contamination	Collect surficial soil samples for analysis
• Lithology of vadose zone	Collect core samples of vadose zone for development of geologic log; determine physical properties of selected samples
• Subsurface water conditions and chemical and radiological characteristics	Collect core samples (visual inspection and physical testing); collect water samples for analysis
• Nature and extent of contaminants in vadose zone	Collect vadose zone samples for analysis

(Note: Sample locations and methods are provided in Section 4. Also provided in Section 4 are the sample analysis and handling procedures including a tabulation of the analytes for the various matrices.)

Table 4-1
BOREHOLE LOCATION RATIONALE

Borehole Identification Number	Description of Borehole Location	Location Rationale
Downgradient of French Drain System		
SEP-01-SB90 SEP-02-SB90 SEP-03-SB90 SEP-04-SB90 SEP-21-SB90 SEP-26-SB90 SEP-27-SB90	Located near the lateral extent of the interpreted nitrate plume in unconfined groundwater system[a]	Evaluate lateral extent of vadose zone contamination and relationship between groundwater contaminant plume and soils/vadose zone contaminants
SEP-05-SB90	Located downgradient of French drains and near longitudinal axis of the interpreted nitrate plume in the unconfined groundwater system[a]	Same as for boreholes 1, 2, 3, and 4
SEP-06-SB90	Located downgradient of French drains and near fringe of interpretated sulfate plume in the unconfined groundwater system[b]	Same as for boreholes 1, 2, 3, and 4
Between Ponds and French Drain System		
SEP-07-SB90 SEP-08-SB90 SEP-09-SB90 SEP-10-SB90	Located on a line perpendicular to the apparent longitudinal axis of the interpreted nitrate and sulfate plumes in the unconfined groundwater system[a,b]	Evaluate lateral extent of vadose zone contamination between Solar Evaluation Ponds and French Drain System

Table 4-1
(continued)

Borehole Identification Number	Description of Borehole Location	Location Rationale
Near Solar Evaporation Ponds		
SEP-11-SB90	Located north of Pond 207-A	Evaluate contaminant concentration profile near historical source (leakage from pond)
SEP-12-SB90	Located between Ponds 207-A and 207-B	Same as for borehole 11
SEP-13-SB90	Located near fringe of nitrate plume and near abandoned pond in SW portion of waste management area[a]	Same as for borehole 11 and to evaluate lateral extent of vadose zone contamination and relationship between groundwater contaminant plume and soils/vadose zone contaminants
SEP-14-SB90	Located near outer fringe of the interpreted nitrate plume in unconfined groundwater system in the SE portion on the waste management area[a]	Same as for borehole 13
SEP-15-SB90	Located north of Pond 207-C	Evaluate potential contaminant north of the pond and potential leakage from the pipelines
SEP-16-SB90	Located south of Pond 207-A	Evaluate vadose zone contamination from pond leakage potentially moving to the south

Table 4-1
(continued)

Borehole Identification Number	Description of Borehole Location	Location Rationale
SEP-17-SB90	Located southeast of Pond 207-B south	Evaluate lateral extent of vadose zone contamination and relationship between groundwater contaminant plume and vadose zone contaminants
SEP-18-SB90	Located southwest of Pond 207-A	Same as for SEP-17-SB90
SB-20-SB90	Located east of Pond 207-B (north)	Same as for SEP-11-SB90
SEP-19-SB90	Located outside of the interpreted nitrate plume[a] and within the interpreted Arapahoe sandstone[c] paleo-channel	
In French Drain System Area		
SEP-22-SB90 SEP-23-SB90 SEP-24-SB90 SEP-25-SB90	Located between individual French drain lines	Evaluate nature and extent of contaminant in vadose zone in the area of French Drain System

[a]Nitrate plume in unconfined groundwater system from EG&G, 1990f, Figure 2-10.
[b]Sulfate plume in unconfined groundwater system from EG&G, 1990f, Figure 2-11.
[c]Arapahoe sandstone interpreted channel from EG&G, 1990g.

Table 4-2
ESTIMATED TARGET DEPTHS
FOR VADOSE ZONE BORINGS

Borehole	Ground Surface Elevation (Feet)[a]	Top of Bedrock Elevation (Feet)[a]	Assumed Thickness of Weathered Arapahoe Formation (Feet)[b]	Estimated Target Depth of Boring (Feet)
SEP-01-SB90	5,900	5,900	10	10
SEP-02-SB90	5,860	5,840	10	30
SEP-03-SB90	5,850	5,840	10	20
SEP-04-SB90	5,885	5,882	10	13
SEP-05-SB90	5,885	5,880	10	15
SEP-06-SB90	5,900	5,890	10	20
SEP-07-SB90	5,955	5,946	10	19
SEP-08-SB90	5,960	5,948	10	22
SEP-09-SB90	5,940	5,940	10	10
SEP-10-SB90	5,940	5,940	10	10
SEP-11-SB90	5,970	5,965	10	15
SEP-12-SB90	5,970	5,958	10	22
SEP-13-SB90	5,975	5,968	10	17
SEP-14-SB90	5,960	5,950	10	20
SEP-15-SB90	5,960	5,960	10	10
SEP-16-SB90	5,975	5,963	10	22
SEP-17-SB90	5,970	5,960	10	20
SEP-18-SB90	5,980	5,965	10	25
SEP-19-SB90	5,950	5,945	10	15
SEP-20-SB90	5,960	5,950	10	20
SEP-21-SB90	5,925	5,920	10	15
SEP-22-SB90	5,920	5,900	10	30
SEP-23-SB90	5,910	5,890	10	30
SEP-24-SB90	5,920	5,910	10	20
SEP-25-SB90	5,930	5,920	10	20
SEP-26-SB90	5,880	5,875	10	15
SEP-27-SB90	5,940	5,930	10	20
SEP-28-SB90	5,975	5,965	10	20
SEP-29-SB90	5,980	5,970	10	20
SEP-30-SB90	5,975	5,967	10	18
SEP-31-SB90	5,970	5,967	10	13
SEP-32-SB90	5,970	5,965	10	15
SEP-33-SB90	5,965	5,965	10	10
SEP-34-SB90	5,965	5,960	10	15
SEP-35-SB90	5,970	5,963	10	17
SEP-36-SB90	5,970	5,963	10	17
SEP-37-SB90	5,970	5,960	10	20
SEP-38-SB90	5,973	5,963	10	20
SEP-39-SB90	5,975	5,965	10	20
SEP-40-SB90	5,975	5,965	10	20
SEP-41-SB90	5,965	5,955	10	20
SEP-42-SB90	5,960	5,948	10	22
SEP-43-SB90	5,963	5,955	10	18
SEP-44-SB90	5,965	5,957	10	18

Table 4-2
ESTIMATED TARGET DEPTHS
FOR VADOSE ZONE BORINGS
(continued)

Borehole	Ground Surface Elevation (Feet)[a]	Top of Bedrock Elevation (Feet)[a]	Assumed Thickness of Weathered Arapahoe Formation (Feet)[b]	Estimated Target Depth of Boring (Feet)
SEP-45-SB90	5,962	5,952	10	20
SEP-46-SB90	5,965	5,957	10	18
SEP-47-SB90	5,965	5,955	10	20
SEP-48-SB90	5,965	5,956	10	19
SEP-49-SB90	5,968	5,959	10	19
SEP-50-SB90	5,970	5,960	10	20
SEP-51-SB90	5,970	5,960	10	20
SEP-52-SB90	5,970	5,960	10	20
SEP-53-SB90	5,970	5,962	10	18
SEP-54-SB90	5,975	5,963	10	22
SEP-55-SB90	5,975	5,960	10	15

[a] Elevations interpreted from EG&G, 1989 RCRA Groundwater Monitoring Report, Fig. 2-7, Top of Bedrock Elevation.
[b] Thickness of weathered Arapahoe Formation estimated based on information provided in EG&G, 1988, Solar Evaporation Pond Closure Characterization Report.

Table 4-3
ANALYTE LIST FOR SOLAR EVAPORATION POND INVESTIGATION[a]

Radionuclides

Plutonium 239, 240
Americium 241
Cesium 137
Uranium 233, 234, 235, and 238
Strontium 90
Tritium[c]
Gross alpha
Gross beta
Radon[d]

Metals

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Cesium
Cobalt
Chromium
Copper
Iron
Lead
Lithium[h]
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Sodium
Silver
Thallium
Tin[h]
Vanadium
Zinc

Inorganics[g]

Nitrate/Nitrite
Ammonia (as N)[c]
Sulfate
Total sulfur[b]
Hydroxide
Fluoride
Chloride[e]

Volatile Organics[g]

Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethene (total)
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon Tetrachloride
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
trans-1,3-Dichloropropene
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene
Toluene

Table 4-3
(continued)

Volatile Organics (continued)

Chlorobenzene
Ethyl Benzene
Styrene
Xylenes (Total)
Methylethyl Ketone Peroxide[h]

Semivolatile Organics[g]

Phenol
bis(2-Chloroethyl) ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis(2-Chloroisopropyl) ether
4-Methylphenol
N-Nitroso-Dipropylamine
Hexachloroethane (perchloroethane[h])
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic Acid
bis(2-Chloroethoxy) methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol (para-chloro-meta-cresol)
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethyl Phthalate
Acenaphthylene
2,6-Dinitrotoluene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl Phenyl ether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
N-nitrosodiphenylamine
4-Bromophenyl Phenyl ether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Pyrene
Butyl Benzyl Phthalate
3,3-Dichlorobenzidine
Benzo(a)anthracene
Chrysene
bis(2-ethylhexyl)phthalate
Di-n-octyl Phthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene
ethylene glycol[h]

Table 4-3
(continued)

Miscellaneous

Acidity[c]
Alkalinity[c]
pH[e]
Specific conductance[e]
Dissolved Oxygen[c,f]
Oxidation reduction potential[c,f]

---

[a]Modified after the Draft Interagency Agreement, Attachment 4, "Hazardous Substance List."
[b]Soil/sediment matrix only.
[c]Water matrix only.
[d]Groundwater samples only.
[e]Both field and laboratory determinations.
[f]Field determination only.
[g]For water matrix, perform analysis on unfiltered sample only.
[h]From Draft Interagency Agreement, Attachment 4, "Hazardous Substance List."

Table 4-4
GEOTECHNICAL TESTING

Property	Method
Moisture content and density	ASTM D 2216
Unit Weight	ASTM D 4531
Atterberg Limits[a]	ASTM D 4318
Grain Size Distribution[a]	ASTM D 422

[a]For soil samples only

Appendix C

Table C-1

BACKGROUND TOTAL METAL RESULTS

SEDIMENTS

(CONCENTRATIONS IN mg/kg)

	SILVER	ALUMINUM	ARSENIC	BARIUM	CALCIUM	CHROMIUM	COPPER	IRON	MAGNESIUM	MANGANESE	NICKEL	LEAD	STRONTIUM	VANADIUM	ZINC
NUMBER OF SAMPLES	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
NUMBER OF DETECTS	1	9	1	4	5	8	4	9	4	9	3	9	3	3	9
PERCENT DETECTS	11	100	11	44	56	89	44	100	44	100	33	100	33	33	100
MAXIMUM DETECTED VALUE	6.8	21600	13.0	182	52500	30.4	22.0	22500	4110	303	29.9	25.1	175	50.2	70.3
MINIMUM DETECTED VALUE	6.8	549	13.0	56.2	1810	3.5	8.6	1040	1380	9.0	9.9	2.3	25.2	13.4	6.5
*MEAN	---	6513.9	---	---	2590	13.48	---	8692.2	---	129.39	---	11.33	---	---	31.33
*STANDARD DEVIATION	---	6029.4	---	---	23082	9.87	---	6471.8	---	80.11	---	9.29	---	---	20.24
*COEFFICIENT OF VARIATION	---	0.9256	---	---	8.9***	0.7322	---	0.7446	---	0.6191	---	0.8200	---	---	0.6460
MAXIMUM REPORTED DETECTION LIMIT	7.0	42.1	6.0	140	3340	2.4	16.2	---	3340	---	26.8	---	70.2	33.4	---
MINIMUM REPORTED DETECTION LIMIT	2.3	13.7	2.0	47.0	1180	2.4	5.9	---	1180	---	9.4	---	23.5	11.8	---
APPROPRIATE STATISTICAL METHOD	TP	TIN	TP	TP	TIN	TIN	TP	TIN	TP	TIN	TP	TIN	TP	TP	TIN
*TOLERANCE INTERVAL (UPPER LIMIT)	---	24789	---	---	72551	43.38	---	28308	---	372.20	---	39.502	---	---	92.688
MEAN & 3 STD. DEVIATION	---	24602	---	---	71836	43.09	---	28107	---	369.72	---	39.2	---	---	92.05

Notes: Total Metals not detected in Background Sediments: Sb,Be,Cd,Cs,Co,Li,Hg,Mo,K,Se,Na,Tl,Sn

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-31p. 4-39

Note: Best Available Copy

Table C-2

OTHER BACKGROUND INORGANIC & TOTAL RADIOCHEMICAL RESULTS

SEDIMENTS

	ALPHA pCi/g	BETA pCi/g	U233,U234 pCi/g	U235 pCi/g	U238 pCi/g	Sr89,Sr90 pCi/g	Pu239,Pu240 pCi/g	Am241 pCi/g	Cs137 pCi/g	TRITIUM pCi/ml	Ra226 pCi/g	Ra228 pCi/g	pH
NUMBER OF SAMPLES	9	9	9	9	9	9	9	9	9	9	9	9	9
NUMBER DETECTS	9	9	9	9	9	9	9	9	9	9	9	9	9
PERCENT DETECTS	100	100	100	100	100	100	100	100	100	100	100	100	100
MAX. VALUE	40+/-15	40+/-7	1.2+/-0.2	.1+/-.1	1.3+/-.2	.8+/-.7	.08+/-.02	.02+/-.04	1.4+/-.1	.32+/-.15	1.0+/-.1	2.1+/-.4	7.9
MIN. VALUE	4+/-12	20+/-6	.5+/-.2	0+/-.1	.4+/-.1	-.6+/-.7	0+/-.02	-.01+/-.02	0+/-.1	.12+/-.14	.6+/-.1	1+/-.1	6.1
*MEAN	25.667	29.556	0.800	0.033	0.778	0.122	0.020	-0.001	0.244	0.203	0.756	1.300	7.211
*STD. DEVIATION	11.373	6.801	0.287	0.047	0.322	0.418	0.025	0.010	0.440	0.068	0.107	0.346	0.52
COEFF./VARIATION	0.443	0.230	0.351	1.424***	0.414	3.426***	0.1750***	-10.00***	1.803***	0.335	0.142	0.266	0.072
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN
*T.INTERVAL (U.LIMIT)	60.137	50.168	1.669	0.176	1.755	1.390	0.096	0.029	1.578	0.408	1.079	2.350	9.03
MEAN + 3 STD. DEV.	59.780	49.959	1.661	0.174	1.744	1.376	0.095	0.029	1.564	0.611	1.077	2.338	8.77
MEAN - 3 STD. DEV.	---	---	---	---	---	---	---	---	---	---	---	---	5.65

Notes: Ions not detected in Background Sediment Samples: Nitrate.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-32p. 4-40

Note: Best Available Copy

Table C-3

BACKGROUND TOTAL METAL RESULTS

ROCKY FLATS ALLUVIUM

(CONCENTRATIONS REPORTED IN mg/kg)

	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Ni	Pb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
NUMBER DETECTS	20	70	44	55	60	68	6	14	70	61	70	19	36	39	65	70	41	56	69	10	21	67	65
PERCENT DETECTS	29	100	63	79	86	97	9	20	100	87	100	27	51	56	93	100	59	80	99	14	30	96	93
MAX. VALUE	40.9	40800	41.7	209	19.0	157000	3.2	18.2	69.6	31.6	33700	0.58	4020	31.3	5570	656	41.0	54.2	21.9	226	338	70.0	77.6
MIN. VALUE	2.8	2240	1.2	43.8	1.0	1130	1.3	11.1	4.0	5.5	4670	0.12	1100	3.7	1180	26.6	2.5	8.8	2.6	23.3	27.3	11.7	4.3
*MEAN	---	11831	3.23	68.9	3.63	5702	---	---	17.2	9.58	12584	---	1061	18.4	2261.2	181.3	17.04	17.81	7.72	---	---	27.75	22.67
*STD. DEVIATION	---	6788	6.36	43.7	3.84	18821	---	---	10.5	5.26	5202	---	1146	13.1	1089.6	121.7	10.88	12.82	5.19	---	---	13.55	15.09
COEFF./VARIATION	---	.5737	2.0***	.6343	1.1***	3.3***	---	---	.6105	.5491	.4134	---	1.1***	.7120	.4819	.6713	.6385	.7198	.6723	---	---	.4883	.6656
MAX DET. LIMIT	4.8	---	4.9	50.1	1.3	1170	2.4	24.2	---	6.3	---	0.24	1250	25.5	1170	---	25.5	10.2	4.2	484	48.4	11.7	4.3
MIN DET. LIMIT	2.0	---	1.7	40.4	1.1	1160	1.0	10.1	---	5.1	---	0.083	1010	2.0	1010	---	2.0	8.7	4.2	20.3	20.2	10.7	4.0
APP. STAT. METHOD	TP	TIN	TIN	TIN	TIN	TIN	TIP	TP	TIN	TIN	TIN	TP	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TP	TP	TIN	TIN
*T.INTERVAL(U.LIMIT)	---	25312	15.86	155.8	11.27	43079	---	---	37.9	20.03	22916	---	3336	44.4	4425	422.9	38.65	43.27	18.04	---	---	54.67	52.64
MEAN + 3 STD. DEV.	---	32195	22.3	200.0	15.2	62165	---	---	48.7	25.4	28190	---	4499	57.7	5530	546.4	49.7	56.3	23.3	---	---	68.4	67.94

Notes: Total Metals not detected in Background Borehole Alluvium: Sb,Cs,Se,Na,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-33p. 4-42

Note: Best Available Copy

Table C-4

OTHER BACKGROUND INORGANIC RESULTS

ROCKY FLATS ALLUVIUM

(CONCENTRATIONS REPORTED IN mg/kg)

	SULFIDE	NITRATE	pH
NUMBER OF SAMPLES	70	70	70
NUMBER DETECTS	16	23	70
PERCENT DETECTS	23	33	100
MAX. VALUE	13	4.3	9.1
MIN. VALUE	2	1.1	6.1
*MEAN	---	---	7.846
*STD. DEVIATION	---	---	0.78
COEFF./VARIATION	---	---	0.0994
MAX DET. LIMIT	4	2.2	---
MIN DET. LIMIT	2	1.0	---
APP. STAT. METHOD	TP	TP	TIN
**T.INTERVAL(L.LIMIT)	---	---	6.06
*T.INTERVAL(U. LIMIT)	---	---	9.64
MEAN + 3 STD. DEV.	---	---	10.186
MEAN - 3 STD. DEVIATI	---	---	5.506

Notes:

*Tolerance Intervals not calculated when the number of samples is less than, seven.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-34p. 4-43

Note: Best Available Copy

Table C-5

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

ROCKY FLATS ALLUVIUM

(CONCENTRATIONS IN pCi/gm) (pCi/ml FOR TRITIUM)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	70	70	70	70	70	69	70	21	70	70	55	55
NUMBER DETECTS	70	70	70	70	70	69	70	21	70	70	55	55
PERCENT DETECTS	100	100	100	100	100	100	100	100	100	100	100	100
MAX. VALUE	40+/-16	44+/-7	3.4+/-0.2	0.2+/-0.1	3.2+/-0.2	1.2+/-1.0	0.03+/-0.03	0.01+/-0.03	0.2+/-0.1	0.44+/-0.16	0.9+/-0.1	2.2+/-0.3
MIN. VALUE	3+/-7	6+/-5	0.2+/-0.2	0.0+/-0.1	0.2+/ 0.1	-0.6+/-0.7	-0.01+/-0.02	-0.02+/-0.02	0.0+/-0.1	-0.15+/-0.15	0.4+/-0.1	0.5+/-0.2
MEAN	21.387	23.600	0.633	0.013	0.639	0.055	0.002	-0.002	0.009	0.177	0.629	1.325
*STD. DEVIATION	7.9157	6.6899	0.4322	0.0375	0.3595	0.3586	0.0073	0.0085	0.0368	0.1175	0.3461	0.7575
COEFF./VARIATION	0.3701	0.2835	0.6829	2.9165*	0.5629	6.5117*	2.9984*	-4.4394*	4.2947*	0.6639	0.5502	0.5715
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN
MAX DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
MIN DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
*T.INTERVAL(U. LIMIT)	37.108	36.886	1.491	0.087	1.353	0.768	0.017	0.018	0.082	0.410	1.334	2.868
MEAN + 3 STD. DEV.	45.1343	43.6696	1.9294	0.1254	1.7170	1.1309	0.0242	0.0235	0.1190	0.5295	1.6675	3.5979

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all background borehole samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-35p. 4-44

Note: Best Available Copy

Table C-6

BACKGROUND TOTAL METAL RESULTS

COLLUVIUM

(CONCENTRATIONS REPORTED IN mg/kg)

	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cs	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
NUMBER DETECTS	8	28	20	27	27	28	1	3	28	2	27	28	8	15	22	28	28	21	2	25	28	28	5	27	28
PERCENT DETECTS	29	100	71	96	96	100	4	11	100	7	96	100	29	54	79	100	100	75	7	89	100	100	18	96	100
MAX. VALUE	33.5	22900	6.6	491	22.4	25900	1.8	15.9	26.9	274	28	35900	.44	3090	18.0	5580	747	26.8	3680	36.2	29.9	121	441	58.8	111
MIN. VALUE	2.5	4630	2.4	45.2	2.0	3020	1.8	13.0	6.1	234	6.4	6860	.10	1250	3.8	1540	37.0	3.5	301	9.6	6.6	25.1	285	15.3	23.9
*MEAN	---	10849	3.31	128.8	5.35	8328	---	---	13.8	---	14.5	14798	---	1235	12.4	3177	193.4	15.95	---	16.9	16.2	56.9	---	29.9	53.0
*STD. DEVIATION	---	4808	1.97	96.49	5.51	5550	---	---	5.8	---	5.4	6756	---	691	8.8	1322	156.4	7.48	---	8.2	4.5	24.1	---	12.6	20.1
COEFF./VARIATION	---	.4432	.5952	.7491	1.0	.6664	---	---	.4203	---	.3724	.4565	---	.5595	.7097	.4161	.8087	.4690	---	.4852	.2778	.4236	---	.4214	.3792
MAX DET. LIMIT	2.6	---	2.5	45.4	1.1	---	1.3	12.9	---	258	6.1	---	.13	1220	24.8	---	---	24.8	1290	9.8	---	---	25.8	11.9	---
MIN DET. LIMIT	2.2	---	1.0	45.4	1.1	---	1.1	10.8	---	216.2	6.1	---	.097	1100	22.1	---	---	2.2	1080	9.5	---	---	22.5	11.9	---
APP. STAT. METHOD	TP	TIN	TIN	TIN	TIN	TIN	TIN	TP	TIN	TIP	TIN	TIN	TP	TIN	TIN	TIN	TIN	TIN	TIP	TIN	TIN	TIN	TP	TIN	TIN
*T.INTERVAL(U.LIMIT)	---	21663	7.7	345.8	17.75	20811	---	---	26.8	---	26.7	29991	---	2789	32.1	6151	545.1	32.78	---	35.4	26.4	111.1	---	58.2	98.1
MEAN+3 STD. DEV.	---	25273	9.2	418.3	21.9	24978	---	---	31.2	---	30.7	35066	---	3308	38.8	7143	662.6	38.4	---	41.5	29.7	129.2	---	67.7	113.3

Notes: Total Metals not detected in Background Borehole Colluvium: Sb,Se,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-36p. 4-46

Note: Best Available Copy

Table C-7

OTHER BACKGROUND INORGANIC RESULTS

COLLUVIUM

(CONCENTRATIONS REPORTED IN mg/kg)

	SULFIDE	NITRATE	pH
NUMBER OF SAMPLES	28	28	28
NUMBER DETECTS	6	15	28
PERCENT DETECTS	21	54	100
MAX. VALUE	5	3.7	9.1
MIN. VALUE	2	1.1	7.2
*MEAN	---	1.35	8.221
*STD. DEVIATION	---	1.30	0.49
COEFF./VARIATION	---	0.9629	0.0596
MAX DET. LIMIT	4	1.3	---
MIN DET. LIMIT	2	1.1	---
APP. STAT. METHOD	TP	TIN	TIN
**T.INTERVAL(L.LIMIT)	---	---	6.96
*T.INTERVAL (U.LIMIT)	---	4.274	9.48
MEAN + 3 STD. DEV.	---	5.25	9.691
MEAN - 3 STD. DEVIATI			6.751

Notes:

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-37p. 4-47

Note: Best Available Copy

Table C-8

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

COLLUVIUM

(CONCENTRATIONS IN pCi/gm) (pCi/ml FOR TRITIUM)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	28	28	28	28	28	28	28	0	28	28	21	21
NUMBER DETECTS	28	28	28	28	28	28	28	0	28	28	21	21
PERCENT DETECTS	100	100	100	100	100	100	100	0	100	100	100	100
MAX. VALUE	48+/-17	34+/-6	2.6+/-0.5	0.2+/-0.1	2.3+/-0.4	0.8+/-0.7	0.02+/-0.02	---	0.2+/-0.1	0.24+/-0.16	1.3+/-0.1	2.1+/-0.3
MIN. VALUE	19+/-10	20+/-6	0.4+/-0.1	0.0+/-0.1	0.4+/-0.2	-0.6+/-0.8	0.00+/-0.02	---	0.0+/-0.1	-0.14+/-0.15	0.7+/-0.1	1.1+/-0.2
*MEAN	31.536	26.750	0.839	0.043	0.925	-0.011	0.006	---	0.014	0.060	1.067	1.567
*STD. DEVIATION	8.9701	3.7285	0.4091	0.0562	0.3334	0.3498	0.0077	---	0.0440	0.1064	0.6433	0.9494
COEFF./VARIATION	0.2844	0.1394	0.4875	1.3123*	0.3604	-32.6514*	1.2712*	---	3.0822*	1.7831*	0.6031	0.6060
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	---	TIN	TIN	TIN	TIN
MAX DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
MIN DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
*T.INTERVAL(U. LIMIT)	51.710	35.135	1.759	0.169	1.675	0.776	0.023	---	0.113	0.299	2.592	3.818
MEAN + 3 STD. DEV.	58.4461	37.9355	2.0667	0.2116	1.9252	1.0388	0.0292	---	0.1464	0.3787	2.9966	4.4148

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all background borehole samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal *Distribution*

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-38p. 4-48

Note: Best Available Copy

Table C-9

BACKGROUND TOTAL METAL RESULTS

WEATHERED CLAYSTONE

(CONCENTRATIONS REPORTED IN mg/kg)

	Ag	Al	As	Ba	Be	Ca	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Ni	Pb	Sb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
NUMBER DETECTS	3	17	9	16	17	17	2	17	17	17	6	4	12	16	17	12	13	17	2	17	2	16	17
PERCENT DETECTS	18	100	53	94	100	100	12	100	100	100	35	24	71	94	100	71	76	100	12	100	12	94	100
MAX. VALUE	18.7	13900	10.8	243	16.1	9970	29.7	13.7	26.7	38100	.35	1400	10.4	5600	737	12.1	62.4	29.5	16.2	141	274	46.4	99.5
MIN. VALUE	2.4	3160	2.6	47.9	1.2	3120	15.3	3.0	6.5	2940	.18	1290	2.7	1510	11.6	2.8	10.2	10.8	13.6	29.7	190	11.0	24.1
*MEAN	---	7430	2.9	100.6	3.5	5762	---	8.98	16.8	14794	---	---	11.97	2320	178	12.36	17.19	20.1	---	75.04	---	22.7	63.2
*STD. DEVIATION	---	2440	4.88	56.1	3.4	1778	---	3.05	5.6	10660	---	---	8.61	1036	192	8.58	15.99	5.8	---	27.91	---	9.3	17.6
COEFF./VARIATION	---	.3284	1.7***	.5577	.9714	.3086	---	.3396	.3274	.7206	---	---	.7193	.4466	1.1***	.6942	.9302	.2886	---	.3719	---	.4097	.2769
MAX DET. LIMIT	2.6	---	2.5	46.9	---	---	12.9	---	---	---	.13	1290	24.8	1060	---	24.8	9.4	---	2.5	---	25.8	10.6	---
MIN DET. LIMIT	2.1	---	2.1	46.9	---	---	10.6	---	---	---	.11	1060	2.1	1060	---	2.1	8.5	---	2.1	---	21.2	10.6	---
APP. STAT. METHOD	TP	TIN	TIN	TIN	TIN	TIN	TP	TIN	TIN	TIN	TP	TP	TIN	TIN	TIN	TIN	TIN	TIN	TP	TIN	TP	TIN	TIN
*T.INTERVAL(U.LIMIT)	---	13495	15.05	240.1	11.8	10183	---	16.57	30.62	41295	---	---	33.37	4896	656	33.68	56.95	34.5	---	144.42	---	47.7	106.7
MEAN + 3 STD. DEV.	---	14750	17.5	268.9	13.7	11096	---	18.13	33.3	46774	---	---	37.8	5428	754	38.1	65.2	37.5	---	158.8	---	50.6	115.7

Notes: Total Metals not detected in Background Borehole Claystone: Cd,Cs,Se,Na,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-39p. 4-49

Note: Best Available Copy

Table C-10

OTHER BACKGROUND INORGANIC RESULTS

WEATHERED CLAYSTONE

(CONCENTRATIONS REPORTED IN mg/kg)

	SULFIDE	NITRATE	pH
NUMBER OF SAMPLES	17	17	17
NUMBER DETECTS	4	7	17
PERCENT DETECTS	24	41	100
MAX. VALUE	5	2.0	9.7
MIN. VALUE	2	1.1	7.6
*MEAN	---	---	8.588
*STD. DEVIATION	---	---	0.54
COEFF./VARIATION	---	---	0.0629
MAX DET. LIMIT	4	1.2	---
MIN DET. LIMIT	2	1.1	---
APP. STAT. METHOD	TP	TP	TIN
**T.INTERVAL(L.LIMIT)	---	---	7.04
*T.INTERVAL (U.LIMIT)	---	---	10.14
MEAN + 3 STD. DEV.	---	---	10.208
MEAN - 3 STD. DEVIATI			6.968

Notes:

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >=

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-40p. 4-50

Note: Best Available Copy

Table C-11

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

WEATHERED CLAYSTONE

(CONCENTRATIONS IN pCi/gm) (pCi/ml FOR TRITIUM)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	17	17	17	17	17	17	17	0	17	17	12	12
NUMBER DETECTS	17	17	17	17	17	17	17	0	17	17	12	12
PERCENT DETECTS	100	100	100	100	100	100	100	0	100	100	100	100
MAX. VALUE	46+/-17	32+/-6	1.7+/-0.4	0.3/-0.1	1.4+/-0.3	0.7+/-0.6	0.01+/-0.02	---	0.0+/-0.1	0.28+/-0.14	1.3+/-0.1	1.6+/-0.2
MIN. VALUE	17+/-14	18+/-6	0.4+/-0.1	0.0+/-0.1	0.5+/-0.2	-0.7+/-0.7	-0.01+/-0.02	---	0.0+/-0.1	-0.11+/-0.15	0.9+/-0.1	1.1+/-0.2
*MEAN	30.059	25.471	1.035	0.047	1.012	-0.118	0.004	---	0.000	0.052	1.100	1.333
*STD. DEVIATION	8.9474	4.1319	0.3819	0.0848	0.2541	0.3634	0.0068	---	0.0000	0.1086	0.7194	0.8773
COEFF./VARIATION	0.2977	0.1622	0.3688	1.8028*	0.2511	-3.0887*	1.9293*	---	---	2.0987*	0.6540	0.6580
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	---	TIN	TIN	TIN	TIN
MAX DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
MIN DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
*T.INTERVAL(U. LIMIT)	52.302	36.743	1.985	0.258	1.643	0.786	0.020	---	0.000	0.322	3.068	3.734
MEAN + 3 STD. DEV.	56.9009	37.8663	2.1809	0.3016	1.7741	0.9725	0.0240	---	0.0000	0.3777	3.2581	3.9652

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all background borehole samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-41p. 4-51

Note: Best Available Copy

Table C-12

BACKGROUND TOTAL METAL RESULTS

WEATHERED SANDSTONE

(CONCENTRATIONS REPORTED IN mg/kg)

	Ag	Al	As	Ba	Be	Ca	Co	Cr	Cu	Fe	Hg	Li	Mg	Mn	Mo	Ni	Pb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
NUMBER DETECTS	1	4	3	3	3	4	1	4	3	4	2	4	3	4	4	2	4	3	1	3	4
PERCENT DETECTS	25	100	75	75	75	100	25	100	75	100	50	100	75	100	100	50	100	75	25	75	100
MAX. VALUE	12.7	10300	3.6	165	2.2	5940	20.5	10.7	19.6	12300	0.27	7.0	2520	305	11.2	14.3	13.4	69.2	268	22.2	79.9
MIN. VALUE	12.7	2470	2.3	47.2	1.7	2310	20.5	3.9	8.1	3040	0.12	2.6	1290	14.9	4.3	10.6	9.4	47.2	268	11.5	38.1
*MEAN	---	5335	2.74	78.89	1.74	3673	---	6.63	9.53	7643	0.11	4.70	1511.1	119.83	7.075	9.57	11.400	47.89	---	14.46	52.75
*STD. DEVIATION	---	3071	0.77	59.92	0.51	1383	---	2.73	6.62	3277	0.11	1.77	657.91	111.81	2.56	3.49	1.42	22.39	---	5.31	16.48
COEFF./VARIATION	---	.5756	.2810	.7595	.2931	.3765	---	.4118	.6946	.4288	1.0	0.3766	0.4354	0.9331	0.3618	0.3647	0.1246	0.4675	---	0.3672	0.3124
MAX DET. LIMIT	2.4	---	2.2	47.9	1.2	---	12.0	---	6.0	---	0.12	---	1200	---	---	9.6	---	23.9	23.9	12.0	---
MIN DET. LIMIT	2.1	---	2.2	47.9	1.2	---	10.7	---	6.0	---	0.11	---	1200	---	---	9.2	---	23.9	21.3	12.0	---
APP. STAT. METHOD	TP	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	TP	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	TP	ANOVA	ANOVA
*T.INTERVAL(U.LIMIT)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MEAN+3 STD. DEV.	---	14548	5.05	259.7	3.27	7822	---	9.36	29.4	17474	44	10.0	3485	455.26	14.75	20.04	15.66	115.1	---	30.39	102.2

Notes: Total Metals not detected in Background Borehole Sandstone: Sb,Cd,Cs,K,Se,Na,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-42p. 4-53

Note: Best Available Copy

Table C-13

OTHER BACKGROUND INORGANIC RESULTS

WEATHERED SANDSTONE

(CONCENTRATIONS REPORTED IN mg/kg)

	SULFIDE	NITRATE	pH
NUMBER OF SAMPLES	4	4	4
NUMBER DETECTS	1	3	4
PERCENT DETECTS	25	75	100
MAX. VALUE	2	1.9	9.2
MIN. VALUE	2	1.2	8.0
*MEAN	---	1.31	8.675
*STD. DEVIATION	---	0.39	0.44
COEFF./VARIATION	---	0.2977	0.0507
MAX DET. LIMIT	3	1.1	---
MIN DET. LIMIT	2	1.1	---
APP. STAT. METHOD	TP	ANOVA	ANOVA
**T.INTERVAL(L.LIMIT)	---	---	---
*T.INTERVAL (U.LIMIT)	---	---	---
MEAN + 3 STD. DEV.	---	2.48	9.995
MEAN - 3 STD. DEVIATI			7.355

Notes:

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-43p. 4-54

Note: Best Available Copy

Table C-14

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

WEATHERED SANDSTONE

(CONCENTRATIONS IN pCi/gm) (pCi/ml FOR TRITIUM)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	4	4	4	4	4	4	4	4	4	4	2	2
NUMBER DETECTS	4	4	4	4	4	4	4	0	4	4	2	2
PERCENT DETECTS	100	100	100	100	100	100	100	---	100	100	100	100
MAX. VALUE	37+/-17	29+/-6	0.8+/-0.3	0.1+/-0.1	1.0+/-0.2	0.4+/-0.6	0.01+/-0.01	---	0.0+/-0.1	0.39+/-0.15	1.0+/-0.1	1.1+/-0.2
MIN. VALUE	19+/-13	20+/-5	0.5+/-0.1	0.0+/-0.1	0.6+/-0.2	-0.7+/-1.0	-0.01+/-0.01	---	0.0+/-0.1	0.00+/-0.15	0.9+/-0.1	1.0+/-0.2
*MEAN	27.000	25.750	0.600	0.025	0.775	-0.175	0.000	---	0.000	0.105	0.950	1.050
*STD. DEVIATION	7.0356	3.6997	0.1225	0.0433	0.1479	0.3961	0.0071	---	0.000	0.1647	0.9513	1.0512
COEFF./VARIATION	0.2606	0.1437	0.2041	1.7321*	0.1908	-2.2633*	---	---	---	1.5685*	1.0014*	1.0011*
APP. STAT. METHOD	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	---	ANOVA	ANOVA	ANOVA	ANOVA
MAX DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
MIN DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
*T.INTERVAL(U. LIMIT)	---	---	---	---	---	---	---	---	---	---	---	---
MEAN + 3 STD. DEV.	48.1069	36.8490	0.9674	0.1549	1.2187	1.0132	0.0212	---	0.0000	0.5991	3.8039	4.2036

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all background borehole samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Modified After:EG&G, 1990h
Table 4-44p. 4-55

Note: Best Available Copy

Appendix D

Appendix D

BASELINE RISK ASSESSMENT PLAN

INTRODUCTION

A baseline risk assessment will be prepared for the Solar Evaporation Ponds as part of the Phase I RFI/RI to evaluate the potential threat to the public health and the environment in the absence of remedial action. The baseline risk assessment will provide the basis for determining whether or not remedial action is necessary in the area and serve as the justification for performing remedial action (U.S. EPA, 1988a).

Several objectives will be accomplished under the risk assessment task including identification and characterization of the following (U.S. EPA, 1988a):

- Toxicity and levels of hazardous substances present in relevant media (e.g., air, groundwater, soil, surface water, sediment, and biota)
- Environmental fate and transport mechanisms within specific environmental media and cross-media fate and transport where appropriate
- Potential human and environmental receptors
- Potential exposure routes and extent of action or expected exposure
- Extent of expected impact or threat; and the likelihood of such impact or threat occurring (i.e., risk characterization)
- Level(s) of uncertainty associated with the above

The public health risk assessment and the environmental evaluation will be performed in accordance with EPA and other guidance documents listed in Table D.1. The risk assessment will address the potential public health and environmental impacts associated with the site under the no-action alternative (no remedial action taken), This assessment will aid in the selection of site remedies based on the contaminants of concern and the environmental media associated with potential risks to public health and the environment.

Table D-1
EPA GUIDANCE DOCUMENTS THAT WILL BE USED IN THE RISK ASSESSMENT TASK

- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual Part A, Interim Final (U.S. EPA, 1989a)
- Superfund Exposure Assessment Manual (U.S. EPA, 1988c)
- Exposure Factors Handbook (U.S. EPA, 1989b)
- The Endangerment Assessment Handbook (U.S. EPA, 1985)
- CERCLA Compliance With Other Laws Manual (U.S. EPA, 1988b)
- Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA, 1988a)
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (U.S. EPA, 1989c)
- Risk Assessment Guidance for Superfund--Environmental Evaluation Manual (U.S. EPA, 1987)
- Data Quality Objectives for Remedial Response Activities: Development Process (U.S. EPA, 1987)

PUBLIC HEALTH EVALUATION

The risk assessment process is divided into four tasks (U.S. EPA, 1988a), including:

1. Contaminant identification
2. Exposure assessment
3. Toxicity assessment
4. Risk characterization

The task objectives and description of work for each task are described below.

CONTAMINANT IDENTIFICATION

The objective of contaminant identification is to screen the information that is available on hazardous substances or wastes present at the site and to identify contaminants for the risk assessment process. Previous work characterizing aspects of the Rocky Flats Plant and the surrounding area has been done. Additional sampling and analysis of various media will take place to support the human health risk assessment, the ecological assessment, and to further characterize the site. Reduction in the number of contaminants identified to a list of "contaminants of concern" will be evaluated in accordance with EPA guidance (U.S. EPA, 1989a).

EXPOSURE ASSESSMENT

The objectives of the exposure assessment are to identify actual or potential exposure pathways, to characterize potentially exposed populations, and to determine the extent of exposure. An exposure pathway is comprised of four elements:

1. A source and mechanism of chemical release to the environment

2. An environmental transport medium (e.g., air, groundwater) for the released constituent

3. A point of potential contact of humans or biota with the affected medium (the exposure point)

4. An exposure route (e.g., inhalation of contaminated dust) at the exposure point

The exposure assessment process will include the following actions:

- Analysis of the probable fate and transport of compounds for both the present and the future uses

- Identification of the human populations in the area, typical activities that would influence exposure, and sensitive population subgroups

- Identification of potential exposure pathways under current and future land use conditions

- Development of exposure scenarios for each identified pathway and select those scenarios that are plausible

- Identification of scenarios assuming both existing and potential future uses

- Identification of the exposure parameters to be used in assessing the risk for all scenarios

- Development of an estimate of the expected exposure levels from the potential release of contaminants

Appropriate exposure scenarios will be identified for the site. Scenarios that could potentially be considered include residential, commercial/industrial, and/or recreational. Factors to be examined in the pathway and receptor identification process will include:

- Location of contaminant source
- Local topography
- Local meteorological data
- Local geohydrology/surface water hydrology
- Surrounding land use
- Local water use
- Prediction of contaminant migration
- Persistence and mobility of migrating contaminants

For each migration pathway, and for current and future conditions, receptors will be identified and characterized. Potential receptors will be defined by the appropriate exposure scenarios.

TOXICITY ASSESSMENT

In accordance with EPA's risk assessment guidelines, the projected concentrations of chemicals of concern at exposure points will be compared with ARARs to judge the degree and extent of risk to public health and the environment (including plants, animals, and ecosystems). Because many ARARs do not exist for certain media (such as soils) nor are all ARARs necessarily health based, this comparison is not sufficient in itself to satisfy the requirements of the risk assessment process. Moreover, receptors may be exposed to contaminants from more than one medium. Nevertheless, the comparison with standards and criteria is useful in defining the exceedance of institutional requirements. Aside form the ARARs listed in Subsection 3.3 of the Phase I RFI/RI Work Plan, the following criteria will be examined:

- Drinking water health advisories

- Ambient water quality criteria for protection of human health

- Center for Disease Control and Agency for Toxic Substances and Disease Registry soil advisories

- National Ambient Air Quality Standards

Critical toxicity values (i.e., numerical values derived from dose-response information for individual compounds) will be used in conjunction with the intake determinations to characterize risk. Toxicity reference values from EPA's Integrated Risk Information System (IRIS) will be used in preference to other EPA reference values.

The baseline risk assessment will also include a summary of any toxicological studies performed for chemicals of concern. The quality of these studies and their usefulness in estimating human health risks will be described. A more detailed explanation of the toxic effects of target chemicals will be provided in the appendices to the human health risk assessment and the environmental evaluation. Toxicity reference values will also be summarized. For the human health risk assessment, this will include a brief description of the studies upon which selected reference values were based; the uncertainty factors used to calculate reference doses (RfDs), and the EPA weight-of-evidence classification for carcinogens. For those chemicals without EPA toxicity reference values, a literature search, including computer data bases, will be conducted for selected compounds. A toxicity value will then, if possible, be derived from this information. EPA will be consulted regarding the appropriateness of the data and the methodologies to be used in deriving reference values. Uncertainties regarding the toxicity assessment will be discussed.

Two types of critical toxicity values will be used:

- The risk RfD
- Slope factor (for carcinogenic chemicals only)

RISK CHARACTERIZATION

Risk characterization involves integrating exposure assumptions and toxicity information to quantitatively estimate the risk of adverse health effects. Risk characterization will be performed in accordance with EPA guidance, and a quantitative risk estimate will be performed for selected chemicals. To assess the potential adverse health effects associated with access to the site, the potential level of human exposure to the selected chemicals must be determined. Intakes of exposed populations will be calculated separately for all appropriate pathways of exposure to chemicals. Then for each population-at-risk, the total intake by each route of exposure will be calculated by adding the intakes from each pathway. Total oral, inhalation, and dermal exposures will be estimated separately. Because short-term (subchronic) exposures to relatively high concentrations of chemicals may cause different non-carcinogenic effects than those caused by long-term (chronic) exposures to lower concentrations, two intake levels will be calculated for non-carcinogens for each route of exposure to each chemical; i.e., a subchronic daily intake (SDI) and a chronic daily intake (CDI). CDIs will be used for exposure to carcinogens. A reasonable maximum estimate of exposure (RME) based on the 95 percent upper confidence limit of the exposure data will be used where applicable. Risk will be quantified by comparison of contaminant intakes at exposure points to quantitative criteria for protection of human health.

An uncertainty analysis will be performed to identify and evaluate non-site and site specific factors that may produce uncertainty in the risk assessment, such as assumptions inherent in the development of toxicological endpoints (potency factors, reference doses). Moreover, site-specific factors, which may produce uncertainty, will also be discussed.

The results of the baseline risk assessment will be used to define and evaluate the remedial alternatives.

ENVIRONMENTAL EVALUATION

The objective of the environmental evaluation for the Solar Evaporation Ponds, Operable Unit No. 3, is to determine if the contaminants have caused or are causing any adverse environmental impact. The data to be collected will be used in conjunction with existing data to determine the bio-availability and toxicity of the contaminants to the flora and fauna of the Solar Evaporation Ponds area.

The environmental evaluation will be conducted per guidance provided in the "Risk Assessment Guidance for Superfund," Volume II, Environmental Evaluation Manual (U.S. EPA, 1989d) as part of the Solar Evaporation Ponds Phase I RFI/RI. The scope of the investigation will include the collection of vegetation, small mammals, arthropods, and aquatic life for determining if bio-accumulation is occurring, where applicable. The radioecology study, Rocky Flats Plant Radioecology and Airborne Pathway Summary Report (Rockwell International, 1986); the Final Environmental Impact Statement (U.S. DOE, 1989); the soils and surface water chemical data; and biological parameters collected during this environmental evaluation will be used to assess both the current and future ecological impacts from the Solar Evaporation Ponds.

Field and laboratory activities will be necessary to determine what effect contaminants at the Solar Evaporation Ponds are having on the area's flora and fauna. These activities may include field assessments, toxicity testing, and biomarkers.

Aquatic and terrestrial field surveys will provide detailed assessments of ecological effects. A field survey for aquatic invertebrates in the creeks downgradient of the Solar Evaporation Ponds will be conducted to determine if these organisms have been adversely affected by contaminants at this site. The survey will include relative abundance, species richness, community organization, and biomass. For comparative purposes, the survey will include a natural background creek area, such as one of those included in the Background Geochemical Characterization Report (Rockwell, 1989).

Toxicity tests will be conducted for the aquatic systems if the aquatic survey indicates an impact. The toxicity of environmental media can be estimated using two approaches: a chemistry-based approach or a toxicity-based approach. The chemistry-based approach will first be applied where chemical analyses of water, air, soil, or sediment will be compared to literature criteria to estimate toxicity. If this analysis fails to explain the contaminant impact on the biota, the toxicity-based approach will be used. The toxicity-based approach involves the measurements of the biological effect associated with exposure to complex mixtures. For this study, toxicity testing will include acute and chronic toxicity methods for aqueous samples.

The concept of biomarkers is that selected endpoints (such as population-ecosystem density, diversity, or nutrient cycling), which are measured in individual organisms, are typically comprised of biochemical or physiological responses that can provide sensitive indices of exposure or sublethal stress. The most direct biomarker to assess exposure is to measure tissue residues, which is a key component of bio-accumulation. Biomarkers for sublethal stress include histopathology, determination of skeletal abnormalities, measurement of gas exchange in plants, and other various measurements (i.e., enzymes). For this evaluation, toxicological endpoints for indicator or target species will be chosen based on a review of available laboratory toxicity tests providing quantitative data for species of concern, when available. In the absence of toxicological indices for the target species, toxicological endpoints will be derived using safety factors that reflect interspecies extrapolation, acute-to-chronic extrapolations, and added protection for endangered and/or threatened species. Procedures to be used for the field and laboratory activities are presented in the "Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (U.S. EPA, 1989c).

In presenting the conclusions of the environmental evaluation for the Solar Evaporation Ponds, the degree of success in meeting the overall objective of the evaluation will be discussed. Each conclusion will be presented along with items of evidence that would support or fail to support the conclusions and the uncertainty accompanying that conclusion. Any factors that limited or prevented development of definitive conclusions will also be described. Information will be provided to indicate the degree of confidence in the data that was used to assess the site and its contaminants.

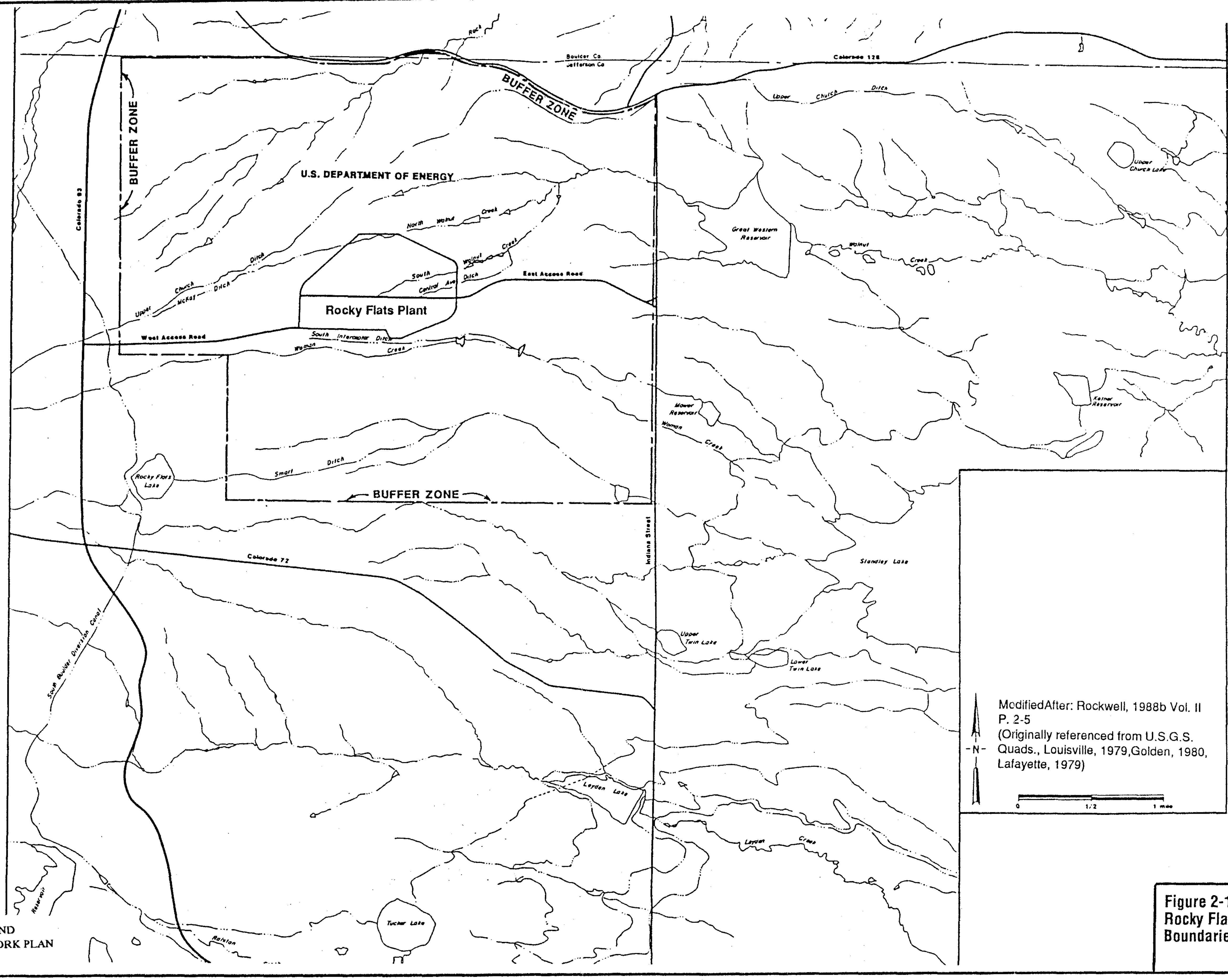
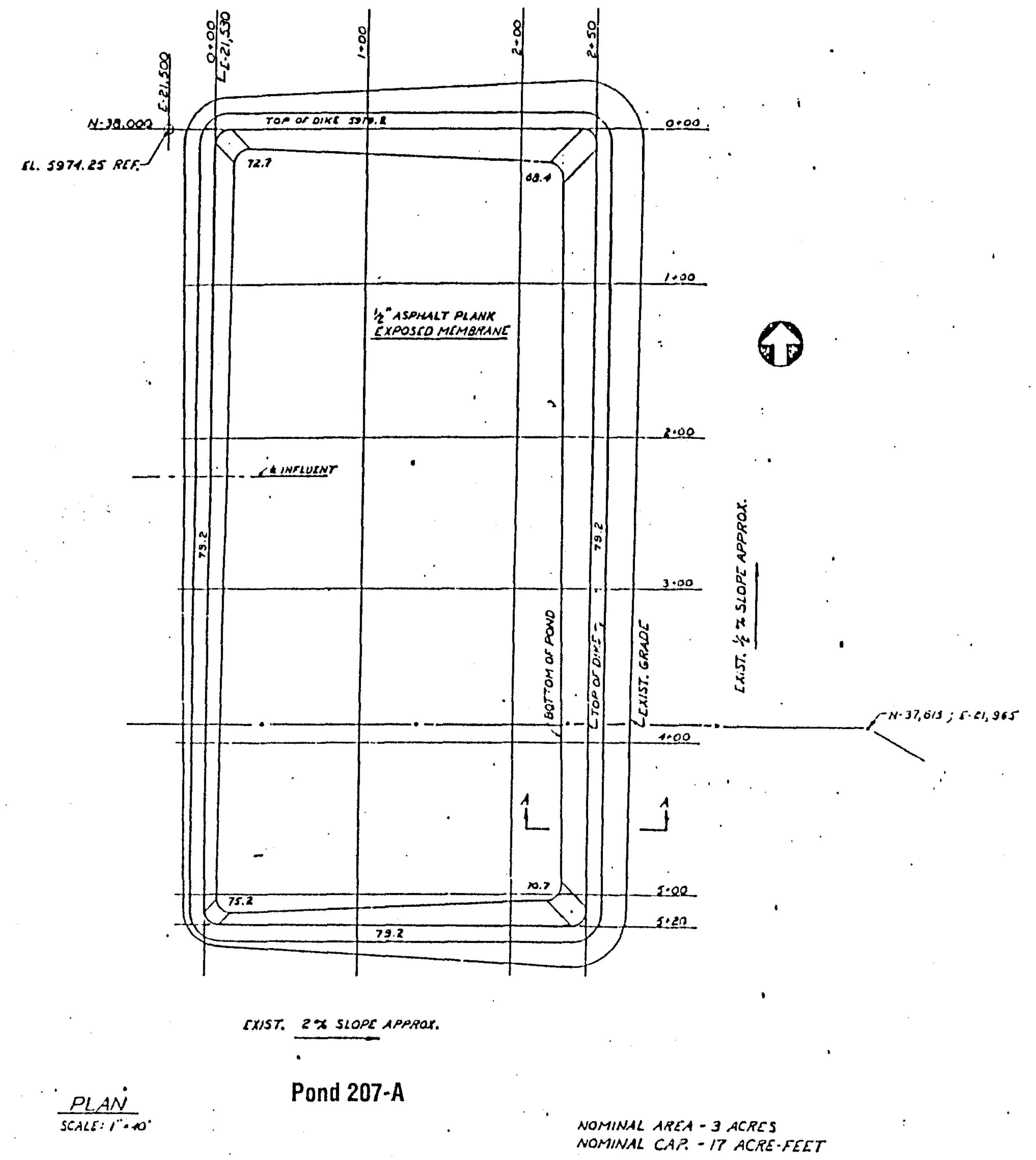
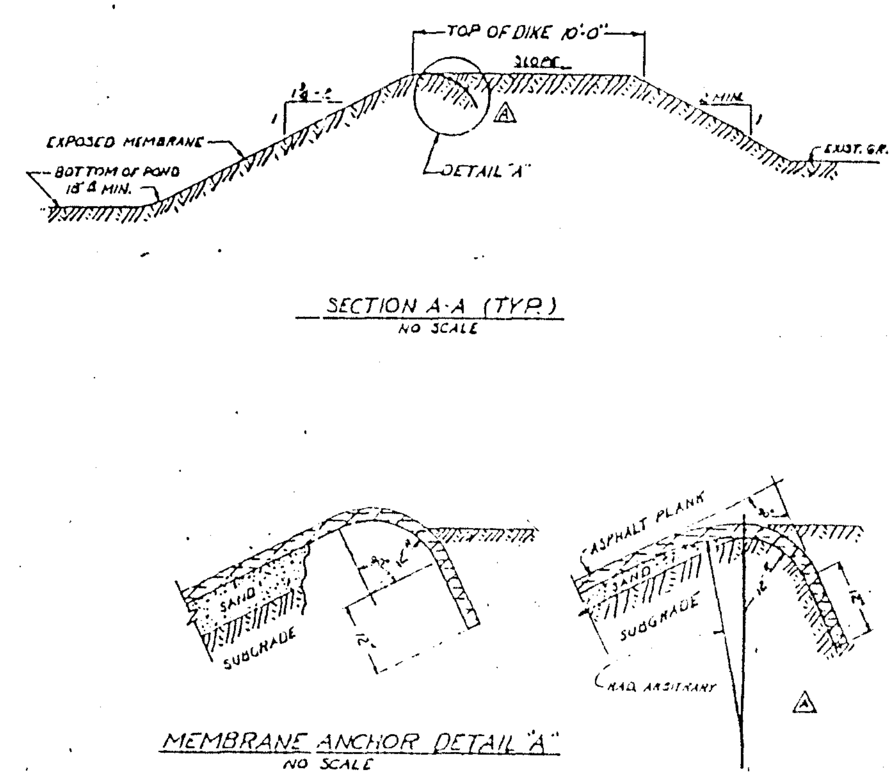


Figure 2-1
Rocky Flats Plant
Boundaries and Buffer Zone



Pond 207-A



NOTES:

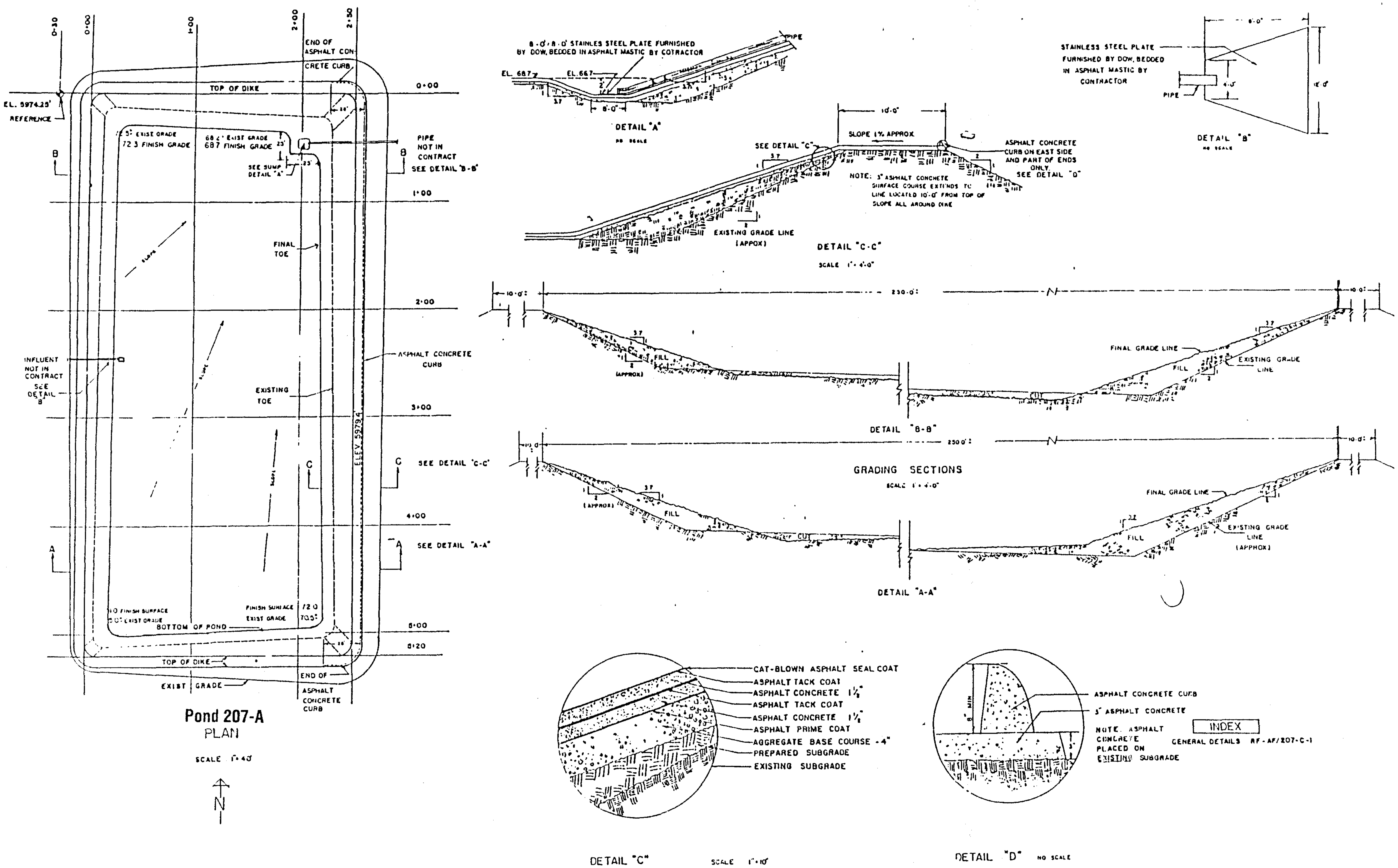
1. MAT'LS & CONSTR. TO CONFORM WITH PROVISIONS OF THE SPECS.
2. INSIDE CORNERS OF POND, TOP & BOTTOM OF DIKE, TO BE 10' RAD.
3. A DOUBLE THICKNESS OF ASPHALT PLANK SHALL BE USED AT THE LOCATION OF THE INFLUENT. THE ADDITIONAL LAYER SHALL BE A MIN. OF 3' WIDE & SHALL EXTEND FROM THE TOP OF THE DIKE TO THE BOTTOM OF THE POND & A DISTANCE OF AT LEAST 10' ALONG THE BOTTOM
4. POND INFLUENT LINE FROM 200,000 GAL. STORAGE TANK BY OTHERS.

SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Modified After: Dow Chemical Drawing 1-3398-207
Note: Best Available Drawing

Figure 2-4
Pond 207-A Plan and Section

JUNE 4, 1990



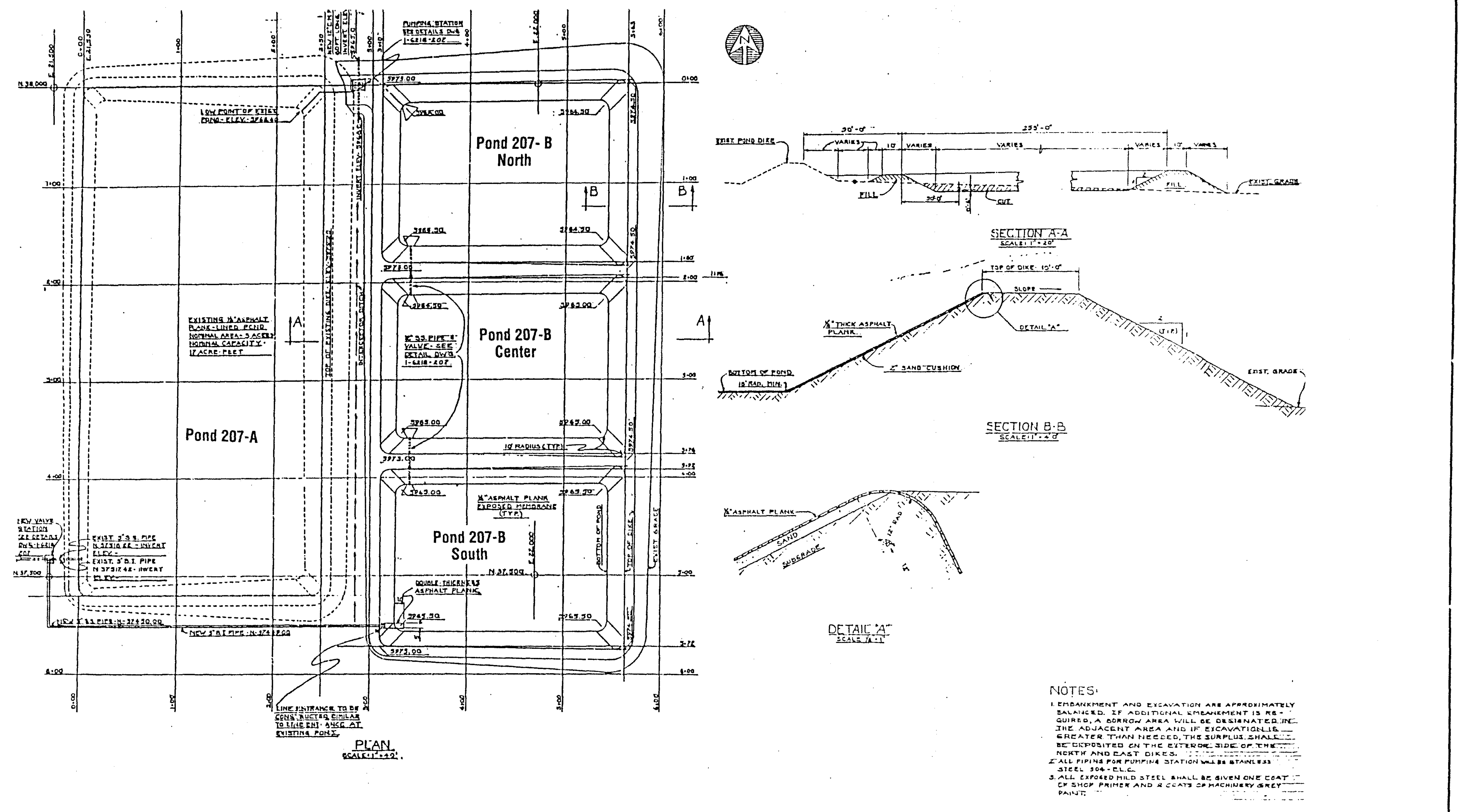
SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Reference, U.S. Atomic Energy Commission
Drawing RF-AF7207-C-T

Note: Best Available Drawing

Figure 2-6
Pond 207-A November 1963
Relining Details

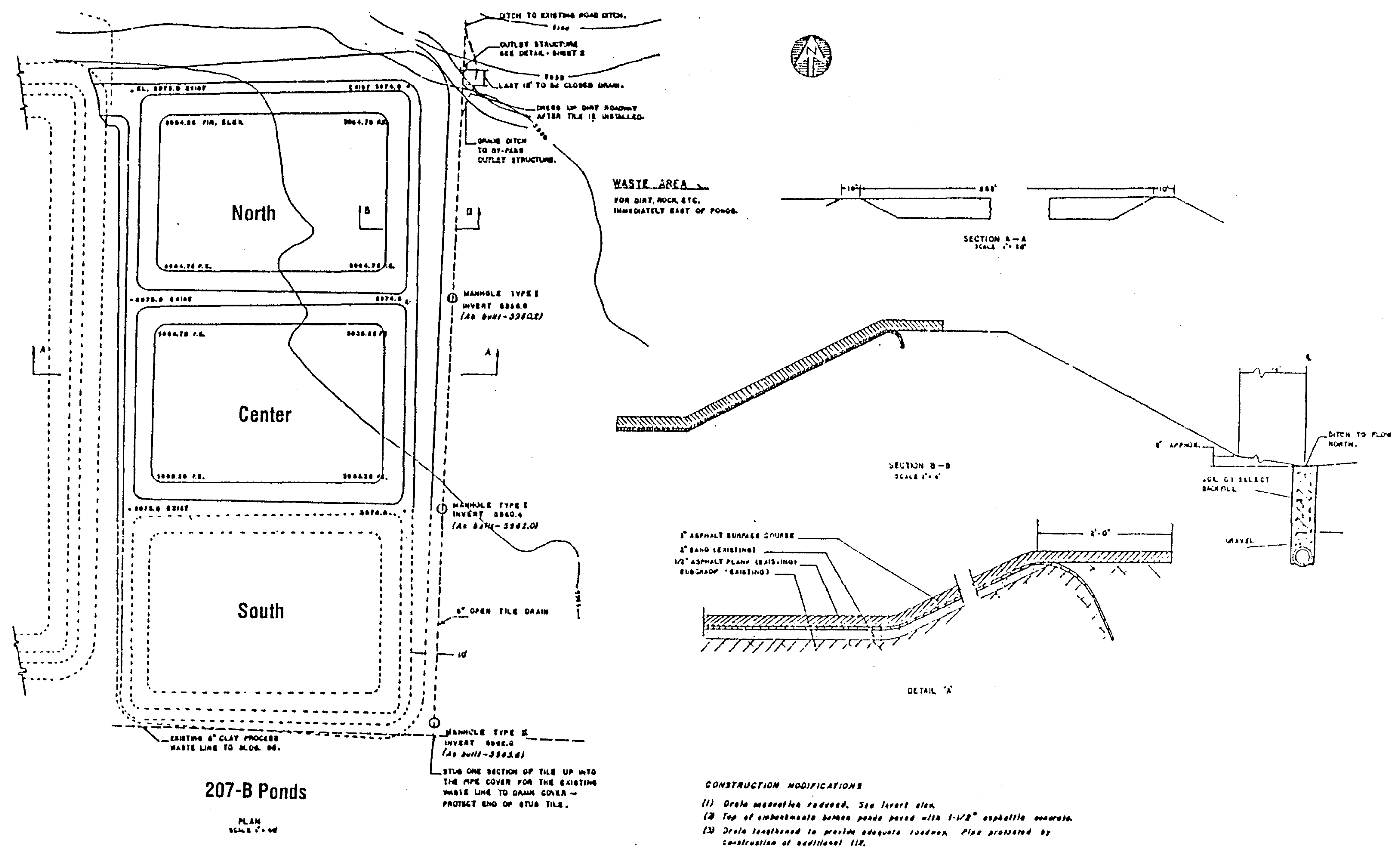
JUNE 4, 1990



SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Modified After: Dow Chemical Drawing 1-6217-207
Note: Best Available Drawing

Figure 2-7
Pond 207-B (North, Center, South)
Plan Sections and Details

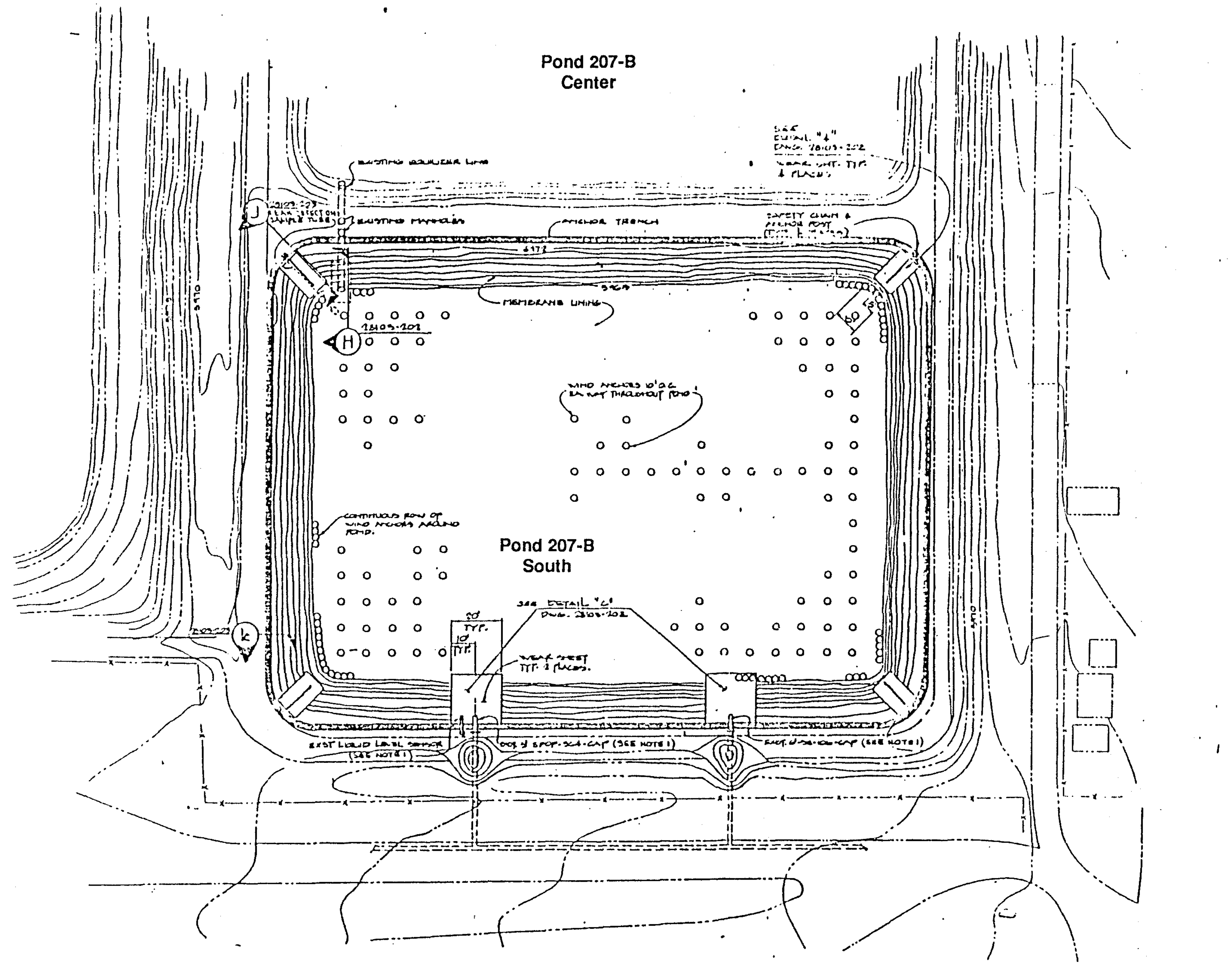


SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Modified After: Dow Chemical Drawing 1-6217-207
Note: Best Available Drawing

Figure 2-8
Pond 207-B (North, Center, South)
August 1961 Relining Details

JUNE 4, 1990



GENERAL NOTES :

1. THE FOLLOWING POND PREPARATION WORK HAS BEEN DONE BY OTHERS:
   A. INSTALLATION OF PIPING.
   B. INSTALLATION OF ANCHOR POSTS.
   C. INSTALLATION OF LEAK DETECTION SAMPLE TUBE.
   D. PREPARATION OF ANCHOR TRENCH FOR PLACEMENT OF MEMBRANE LINING.
   E. INSTALLATION OF CONCRETE APRON AROUND EQUALIZER LINE.

NOTES : (THIS DWG ONLY)

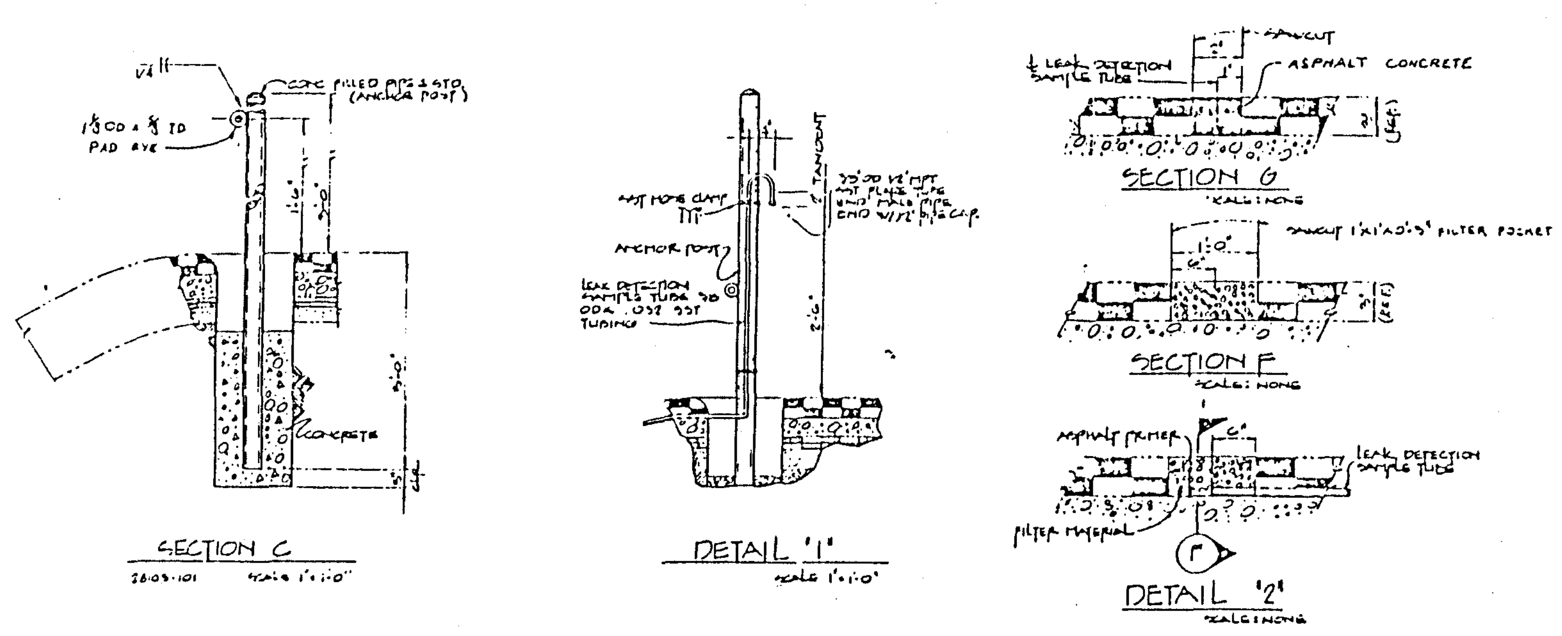
1. THE EXISTING LIQUID LEVEL SENSOR AND POND FILL LINES (3"SPOP 364-CN & 6"SE-106-CN) MAY BE TEMPORARILY DISCONNECTED AT THEIR FLANGES TO FACILITATE WORK AT THE ANCHOR TRENCH.

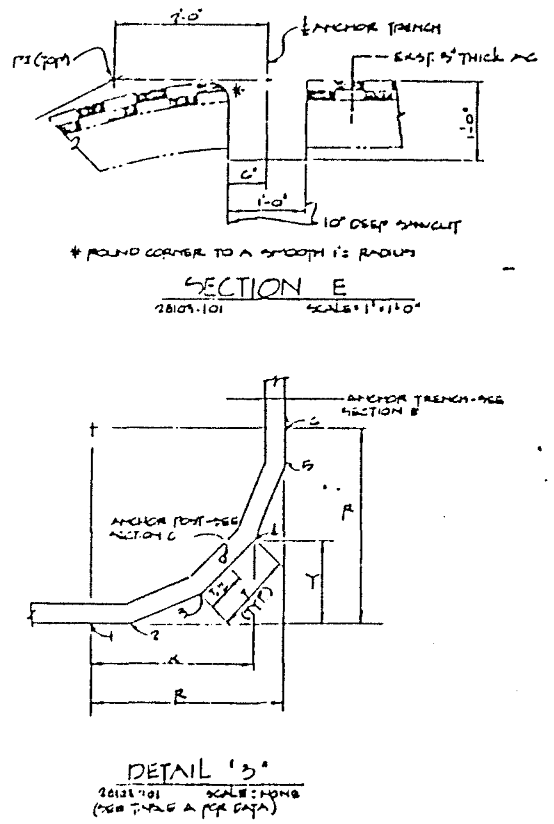
SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Modified After: Dow Chemical Drawing 28103-201
Note: Best Available Drawing

Figure 2-9
Pond 207-B South
1977 Membrane Pond Liner Plan

JUNE 4, 1990

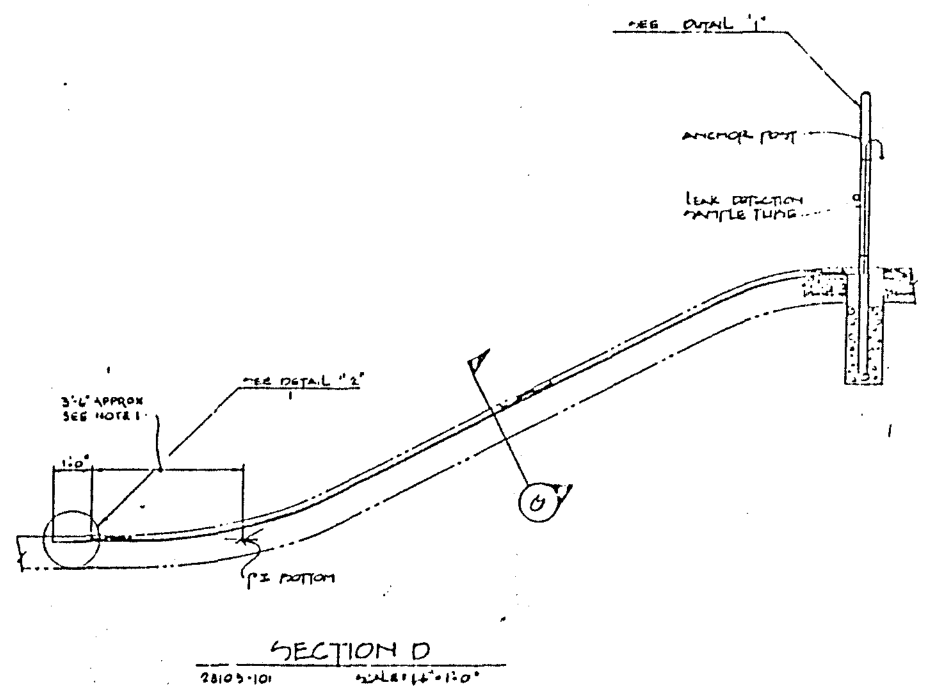




R	T	POINT	X	Y
10	3.96	1	0	0
		2	1.99	0
		3	5.67	1.52
		4	8.45	4.33
		5	10.00	8.01
		6	10.00	10.00
15	5.97	1	0	0
		2	2.93	0
		3	8.50	2.28
		4	12.72	6.60
		5	15.00	12.07
		6	15.00	15.00
20	7.96	1	0	0
		2	3.95	0
		3	11.33	3.04
		4	16.96	8.67
		5	20.00	16.02
		6	20.00	20.00
25	9.95	1	0	0
		2	4.97	0
		3	14.16	3.80
		4	21.20	10.84
		5	25.00	20.03
		6	25.00	25.00

NOTES: 1. ALL DIMENSIONS ARE IN FEET
2. THE APPROPRIATE RADIUS FOR EACH CORNER WILL BE SELECTED BY THE CONTRACTING OFFICER.

TABLE A
(REF. DETAIL '3')

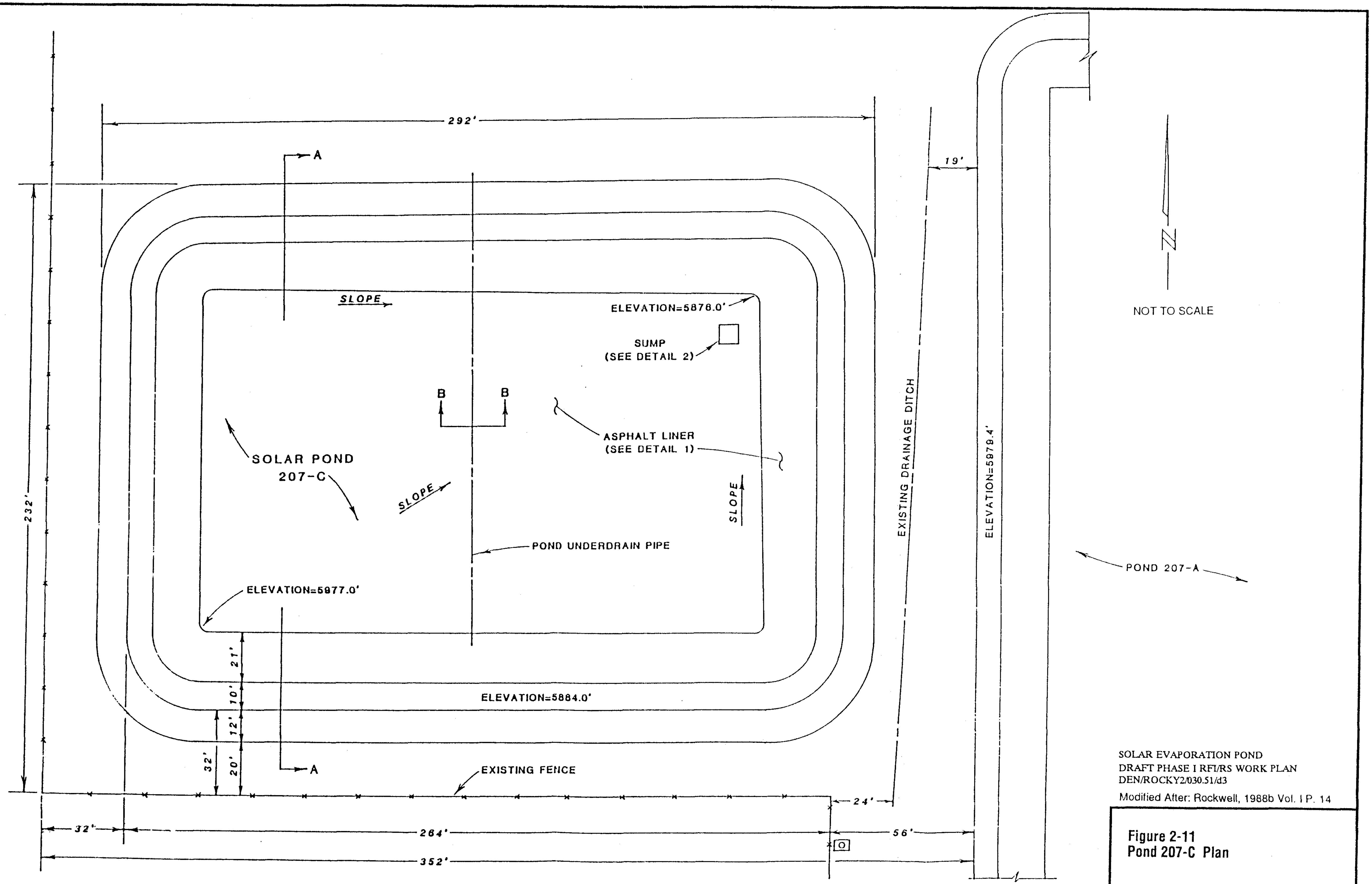


SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Modified After: Dow Chemical Drawing 28103-102
Note: Best Available Drawing

Figure 2-10
Pond 207-B South
Leak Detection System Detail

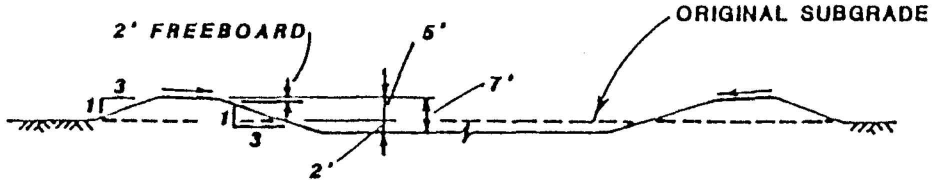
JUNE 4, 1990



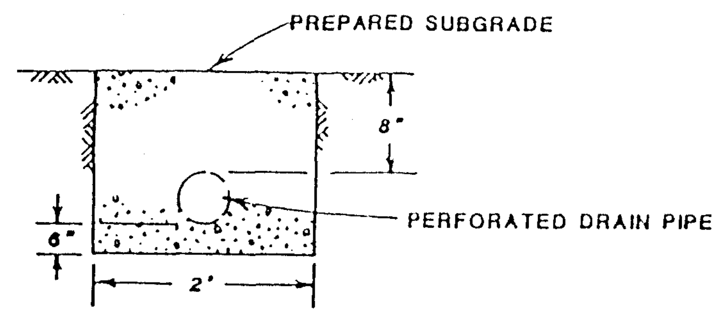
SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Modified After: Rockwell, 1988b Vol. I P. 14

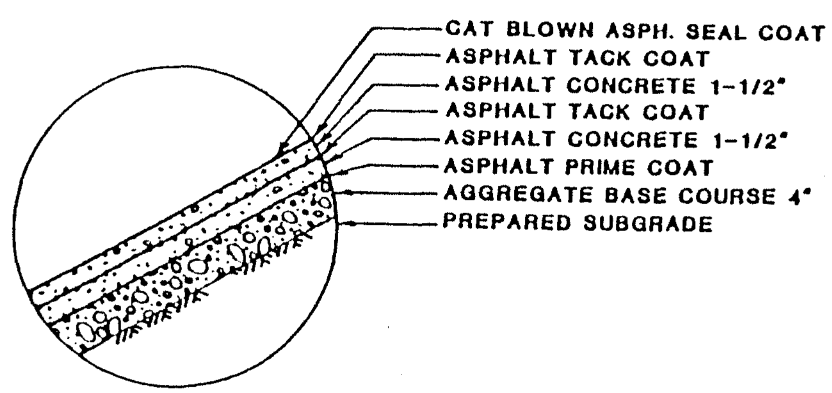
Figure 2-11
Pond 207-C Plan



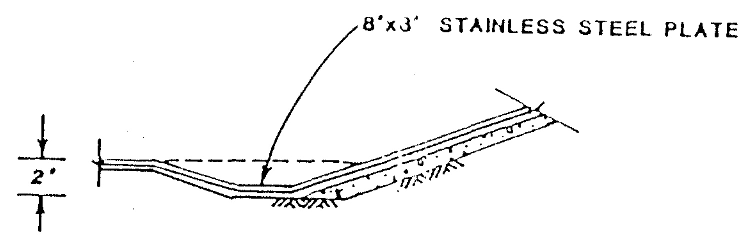
SECTION A–A
NOT TO SCALE



SECTION B–B
NOT TO SCALE



DETAIL 1 – ASPHALT LINER
NOT TO SCALE



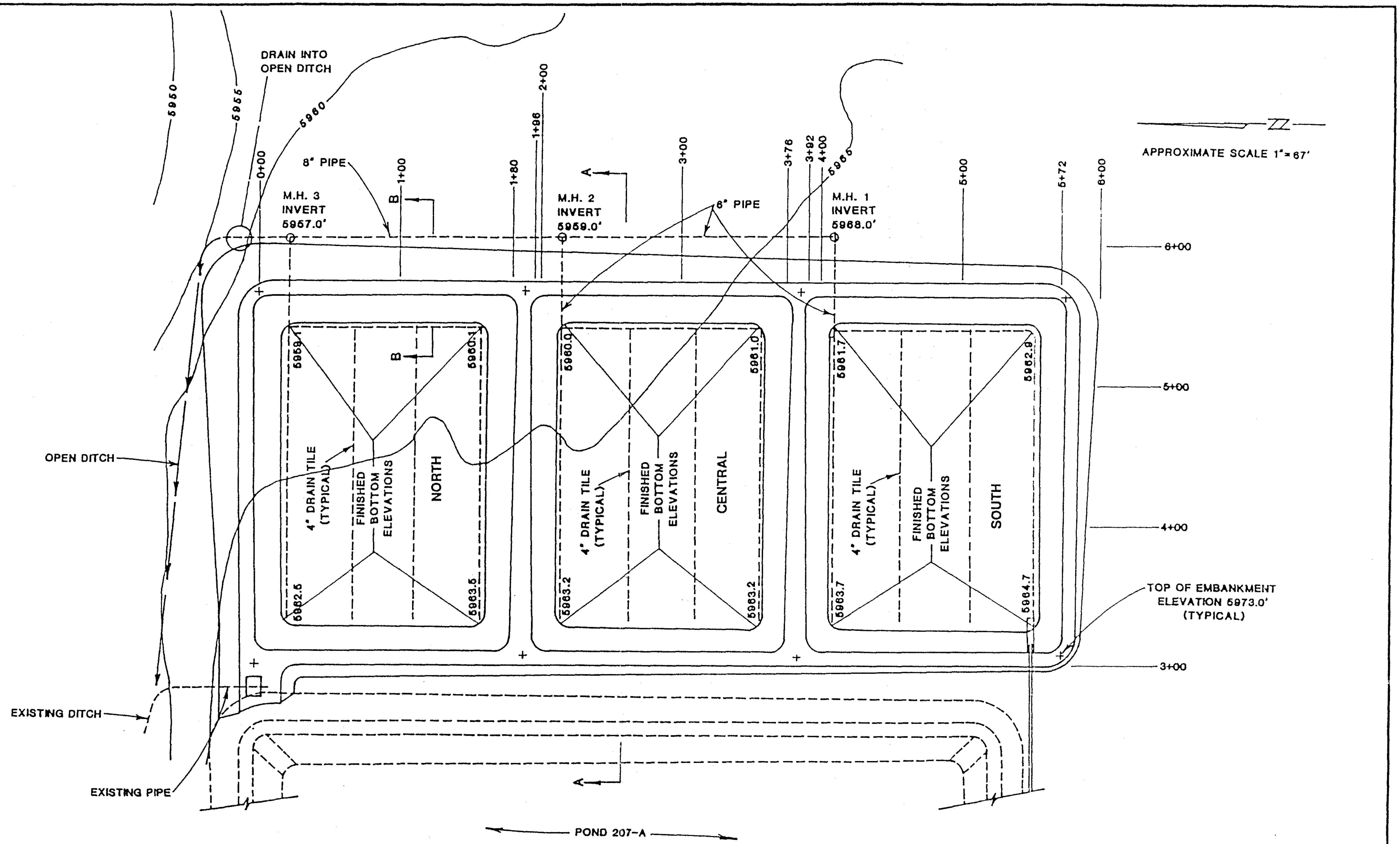
DETAIL 2 – SUMP
NOT TO SCALE

SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY1/027.51/d9

Modified After: Rockwell, 1988b Vol. I P. 15

Figure 2-12
Pond 207-C Liner & Leak Detection System Details

JUNE 4, 1990

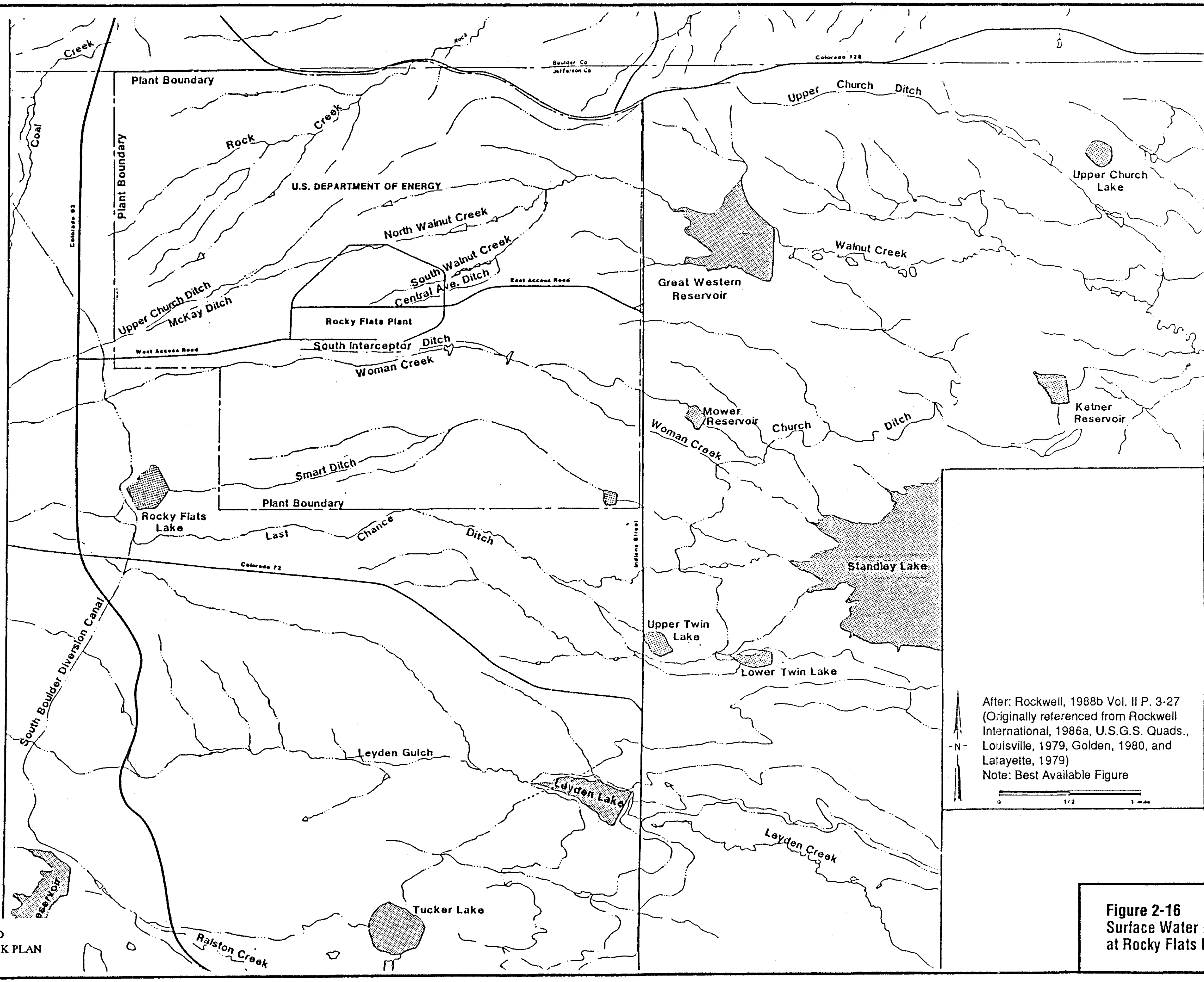


SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Modified After: Rockwell, 1988b Vol. I P. 10

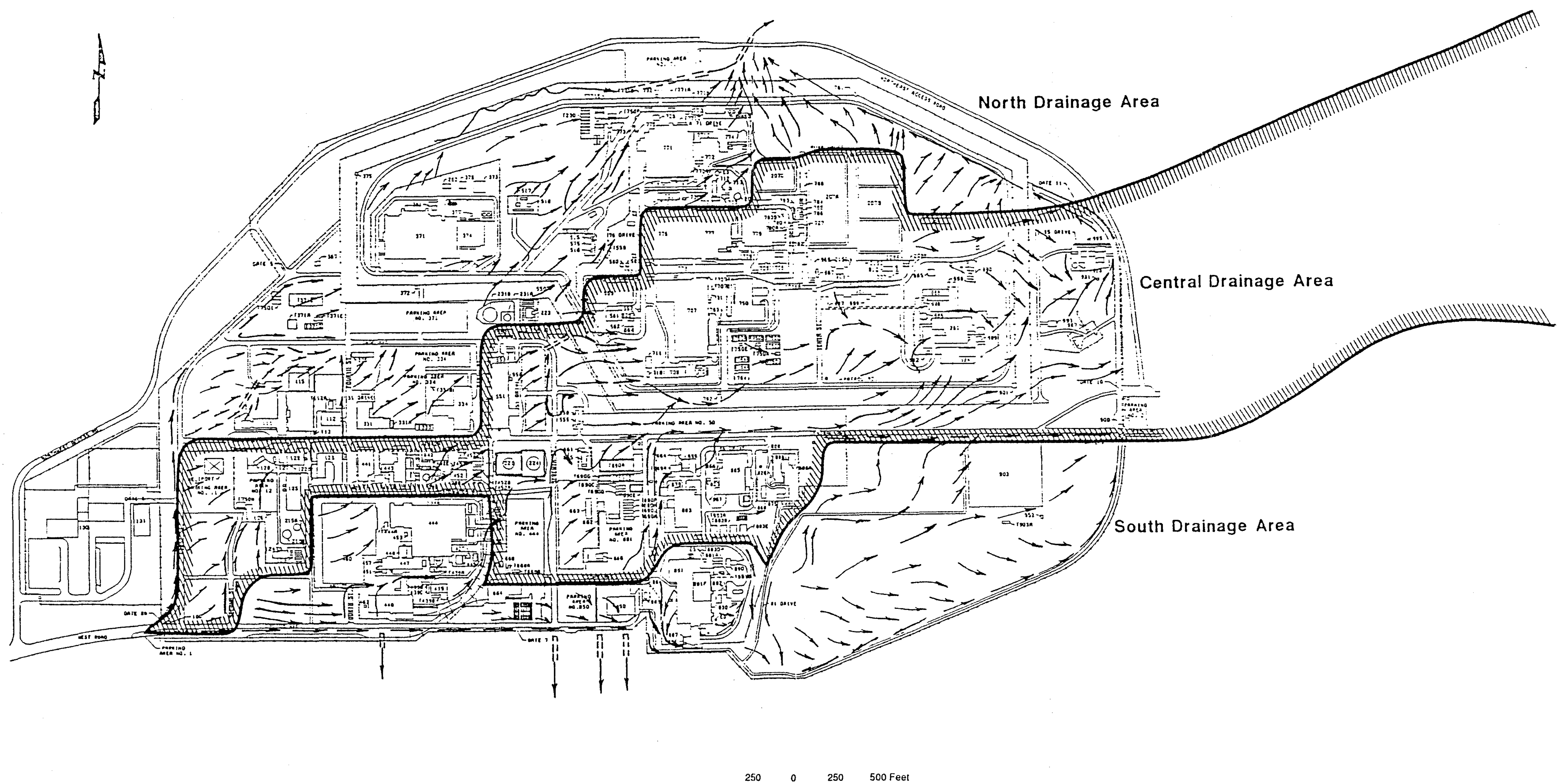
Figure 2-14
Pond 207-B (North, Center, South)
Pond Underdrain Plan

JUNE 4, 1990



After: Rockwell, 1988b Vol. II P. 3-27 (Originally referenced from Rockwell International, 1986a, U.S.G.S. Quads., Louisville, 1979, Golden, 1980, and Lafayette, 1979)
Note: Best Available Figure

Figure 2-16
Surface Water Drainage Patterns at Rocky Flats Plant

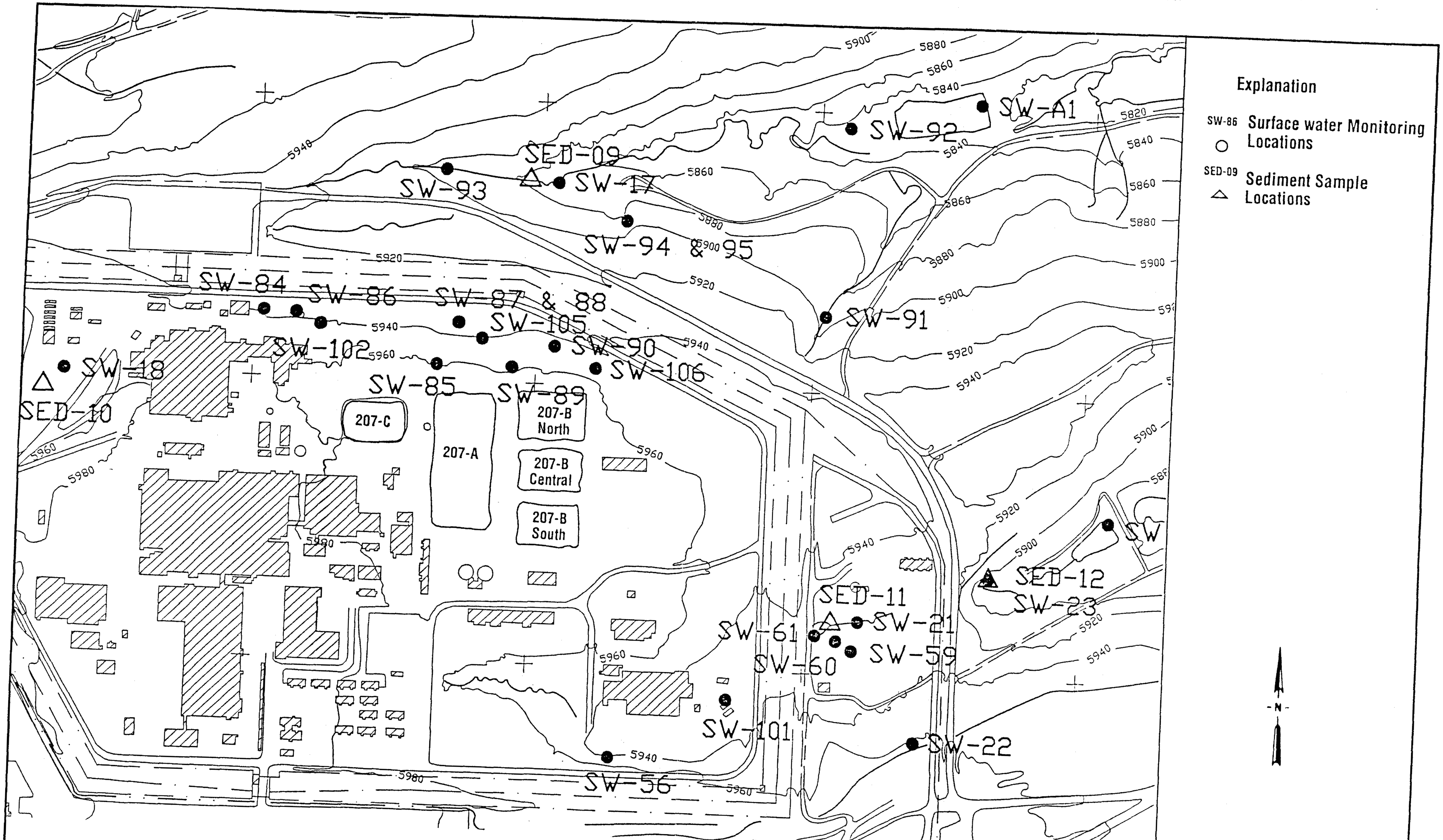


SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY1/027.51/d9

After: Rockwell, 1988b Vol. II P. 6-2 Note: Best Available Drawing

Figure 2-18
Plant Surface Runoff Drainage Pattern

JUNE 4, 1990

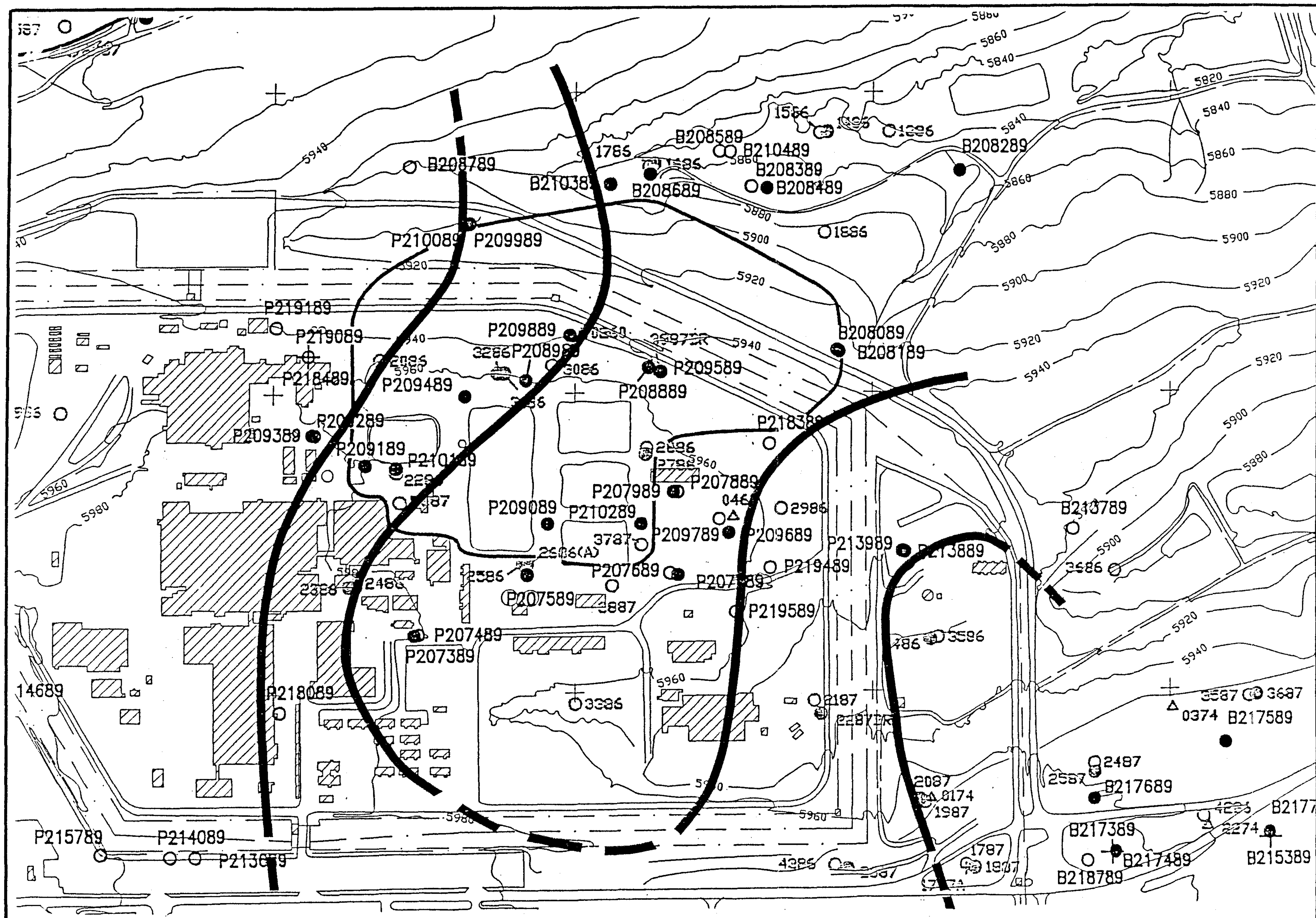


SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

After: EG & G 1990g

Figure 2-19
Surface Water Sample Locations in the Vicinity of the Solar Evaporation Ponds

JUNE 4, 1990



LEGEND

B210489 ○ Alluvial Monitor Well

P209089 ● Weathered Bedrock Monitoring Well

3486 □ Unweathered Bedrock Monitoring Well

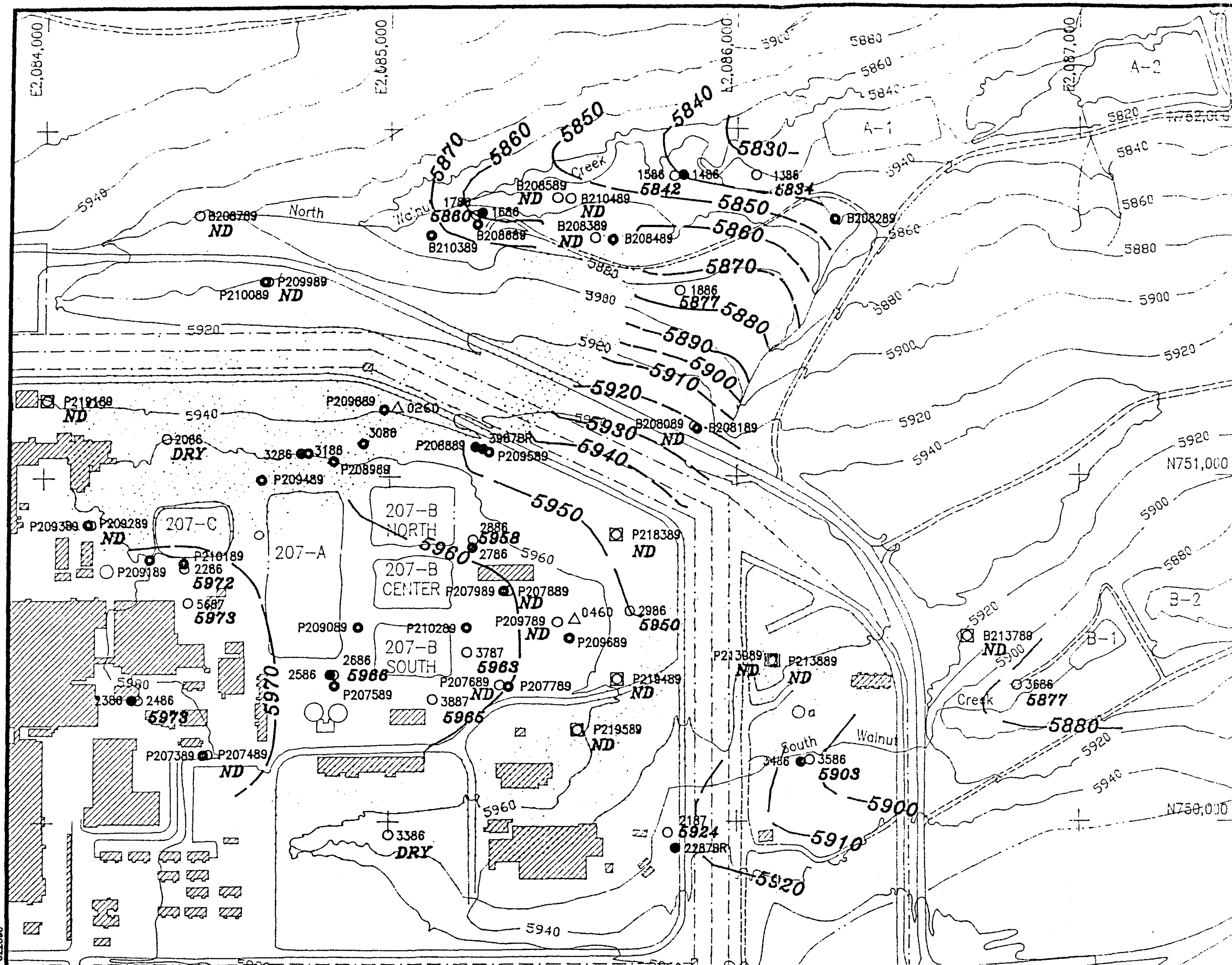
Interpreted Paleo-Channel (dashed where uncertain)

SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY2/030.51/d3

Modified After:EG&G, 1990g

Figure 2-21
Approximate Location of Interpreted Paleo-Channel within Arapahoe Sandstone

JUNE 4, 1990



SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY1/027.51/d9

NOTE:
Potentiometric surface lines are interpreted from second quarter 1989 water level data.

EXPLANATION

B210489 ○ Alluvial Monitoring Well

P209089 ⊙ Weathered Bedrock Monitoring Well

3486 ● Unweathered Bedrock Monitoring Well

0260 △ Pre-1986 Monitoring Well

B213789 ⊠ Piezometer

5961 Potentiometric Surface Elevation May 1989 (feet above mean sea level)

5920 Line of Equal Potentiometric Surface Elevation (feet above mean sea level) Dashed where approximately located Contour Interval – 10 feet

ND No Data – well not yet completed

Unsaturated Surficial Materials – estimated extent

N

0' 150' 300'

CONTOUR INTERVAL = 20'

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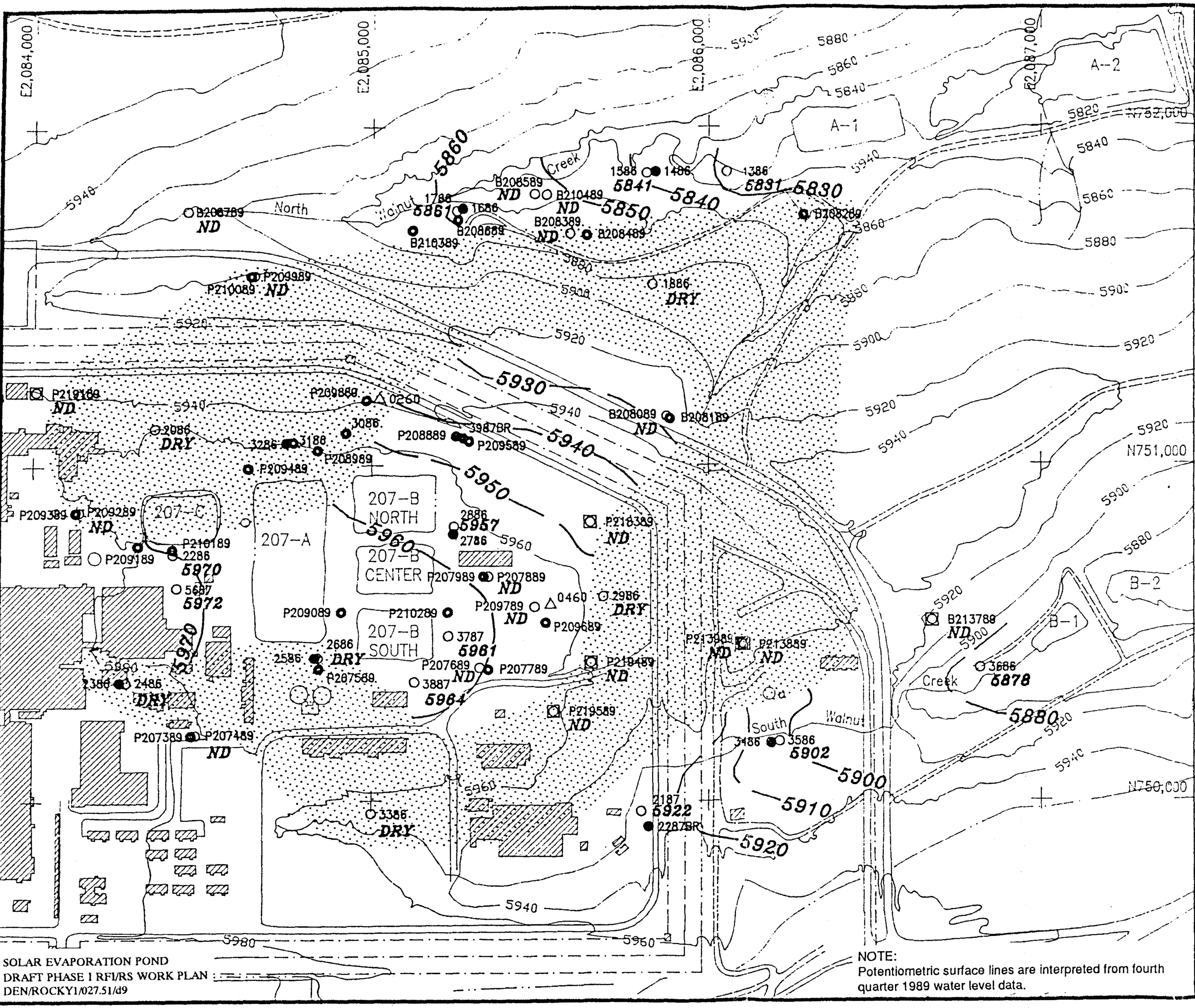
Rocky Flats Plant
Golden, Colorado

Figure 2-23
Potentiometric Surface in Surficial Materials Second Quarter 1989

After: EG & G 1990 Vol. I, Fig. 2-2

SP300D.MRPJ-022090



EXPLANATION

B210489	○	Alluvial Monitoring Well
P209089	◉	Weathered Bedrock Monitoring Well
3486	●	Unweathered Bedrock Monitoring Well
0260	△	Pre-1986 Monitoring Well
B213789	⊠	Piezometer
5961		Potentiometric Surface Elevation November 1989 (feet above mean sea level)
5878		Potentiometric Surface Elevation December 1989 (feet above mean sea level)
5920		Line of Equal Potentiometric Surface Elevation (feet above mean sea level) Dashed where approximately located Contour Interval – 10 feet
ND		No Data – well not yet completed
		Unsaturated Surficial Materials – estimated extent

N

0' 150' 300'

CONTOUR INTERVAL = 20'

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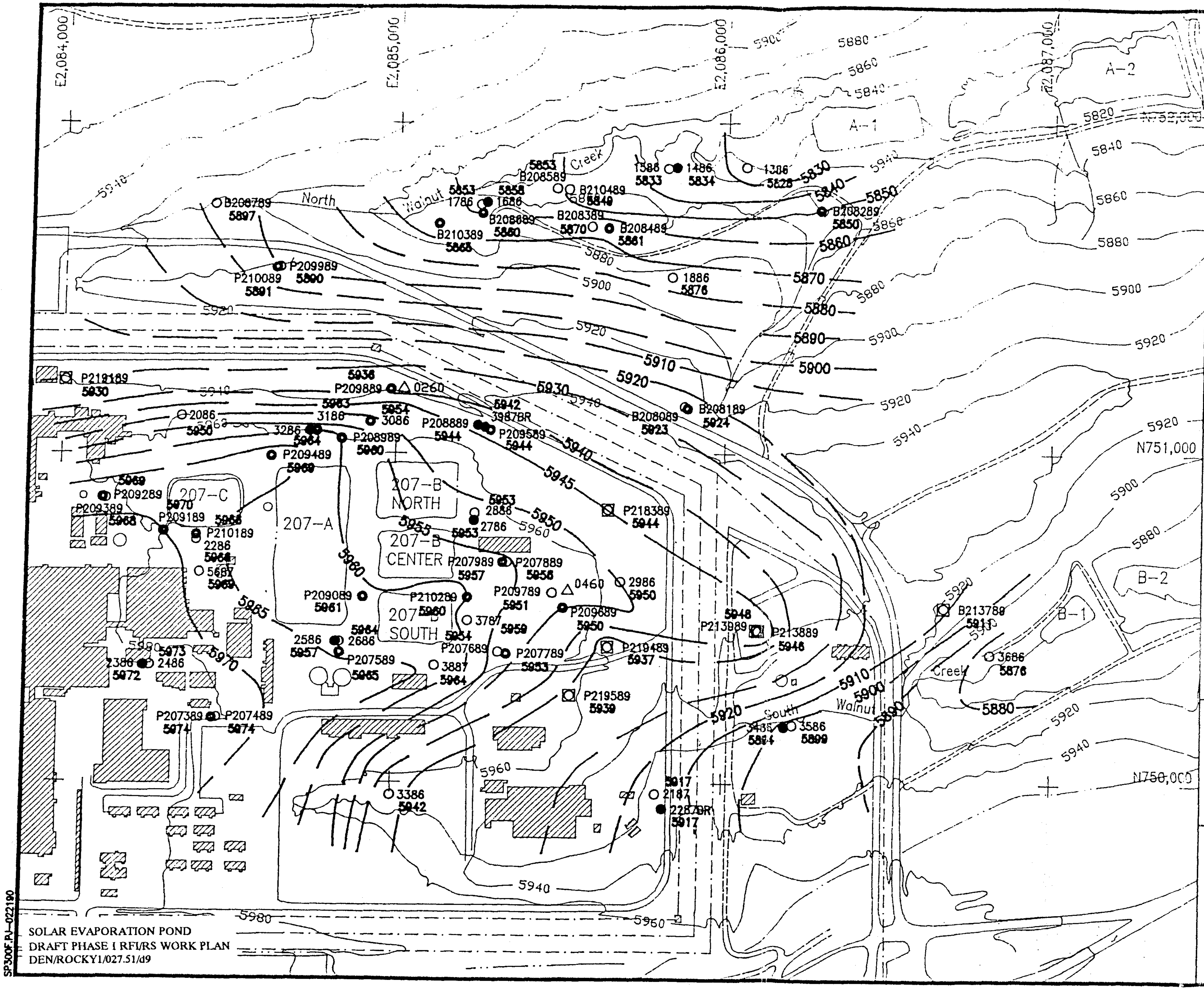
Rocky Flats Plant
Golden, Colorado

Figure 2-24
Potentiometric Surface in Surficial Materials Fourth Quarter 1989

After: EG & G 1990 Vol. I, Fig. 2-6



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Golden, Colorado

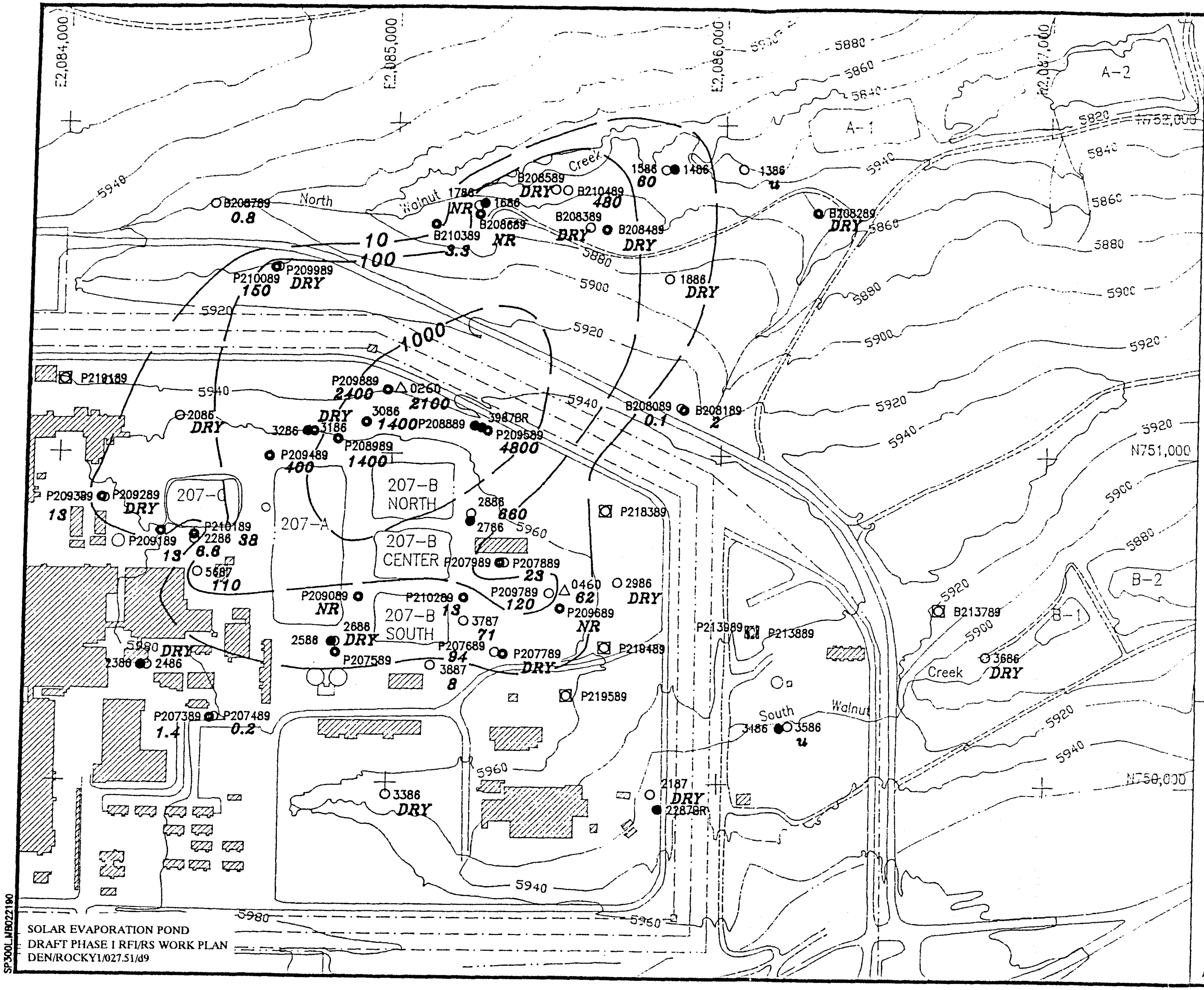
Figure 2-25
Top of Bedrock Surface

After: EG & G 1990 Vol. I, Fig. 2-7

SP300F.PJ-022190

SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY1/027.51/d9

JUNE 4, 1990



EXPLANATION

B210489	○	Alluvial Monitoring Well
P209089	⊙	Weathered Bedrock Monitoring Well
3486	●	Unweathered Bedrock Monitoring Well
0260	△	Pre-1986 Monitoring Well
B213789	⊠	Piezometer
13		Nitrate Concentration in Alluvial Ground Water (mg/l)
13		Nitrate Concentration in Weathered Bedrock Ground Water (mg/l)
10		Line of Equal Nitrate Concentration (mg/l). Dashed where approximately located Contour interval varies
DRY		Insufficient Water for Inorganic Analysis
NR		Data not yet received
u		Nitrate Concentration below detection limit

N

Scale: 1" = 300'

0' 150' 300'

CONTOUR INTERVAL = 20'

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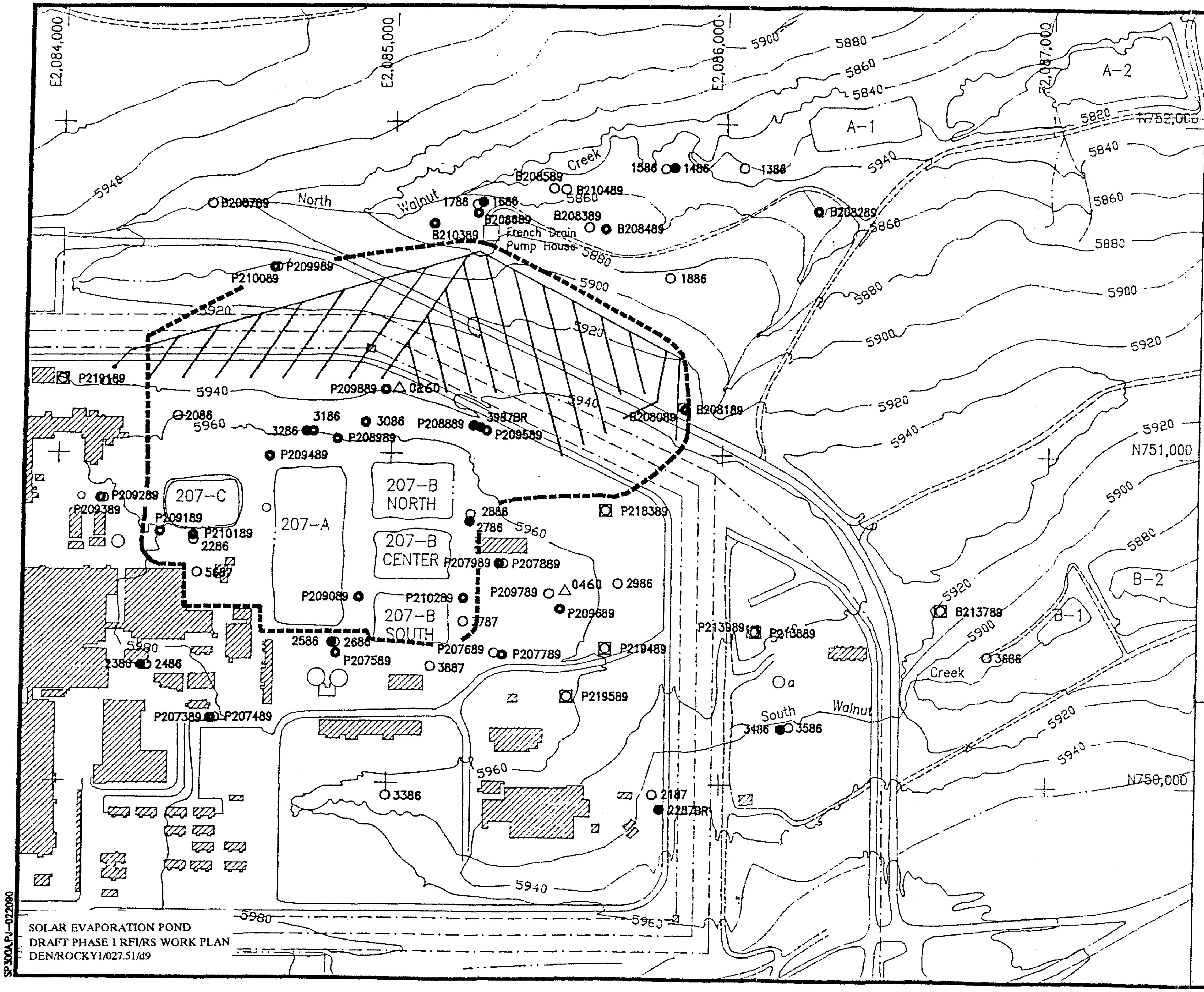
Golden, Colorado

Figure 2-26
Nitrate Concentrations in the Unconfined Ground-Water Flow System

Fourth Quarter 1989

After: EG & G 1990 Vol. I, Fig. 2-10



EXPLANATION

B210489	O	Alluvial Monitoring Well
P209089	ʘ	Weathered Bedrock Monitoring Well
3486	●	Unweathered Bedrock Monitoring Well
0260	△	Pre-1986 Monitoring Well
B213789	⊠	Piezometer

RCRA Waste Management Area

French Drain System

N

Scale: 1" = 300'

0' 150' 300'

CONTOUR INTERVAL = 20'

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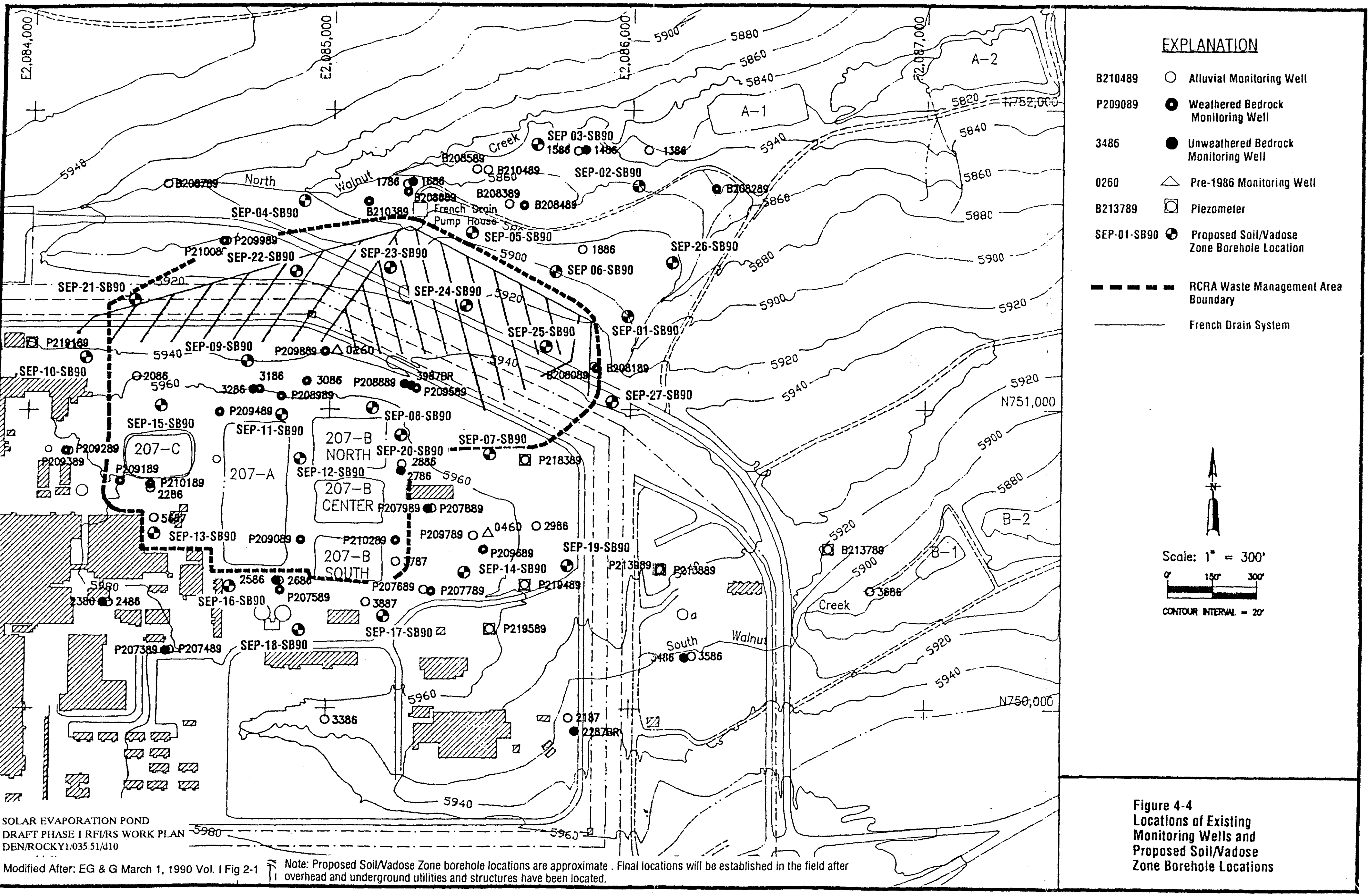
Golden, Colorado

Figure 2-27
Waste Management Area Boundary and Monitoring Well Locations

After: EG & G 1990 Vol. I, Fig. 2-1

SP300A.PJ-022090



SOLAR EVAPORATION POND
DRAFT PHASE I RFI/RS WORK PLAN
DEN/ROCKY1/035.51/d10

Modified After: EG & G March 1, 1990 Vol. I Fig 2-1

Note: Proposed Soil/Vadose Zone borehole locations are approximate. Final locations will be established in the field after overhead and underground utilities and structures have been located.

Figure 4-4
Locations of Existing Monitoring Wells and Proposed Soil/Vadose Zone Borehole Locations

SP300A.PJ-022090

JUNE 4, 1990

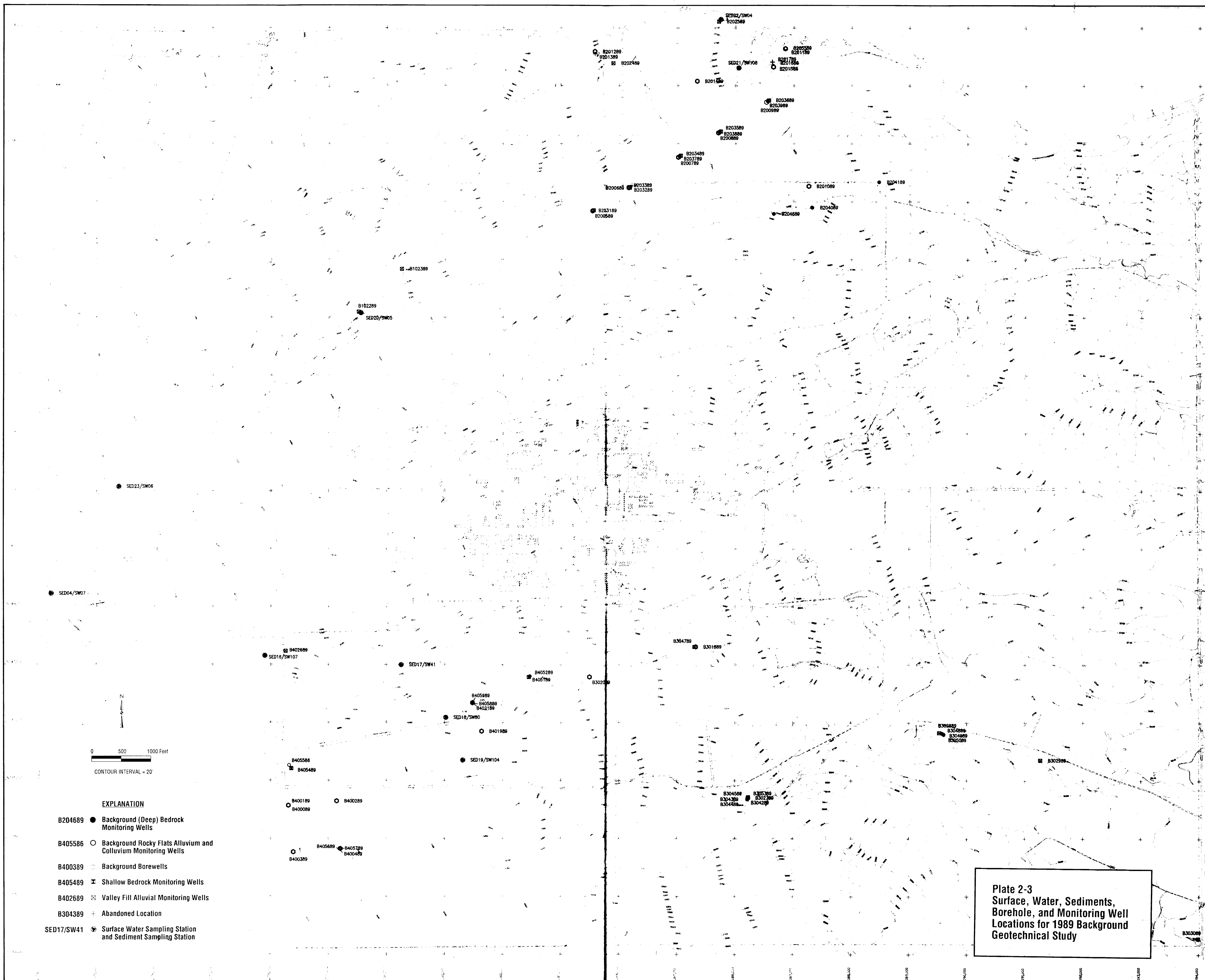


Plate 2-3
Surface, Water, Sediments, Borehole, and Monitoring Well Locations for 1989 Background Geotechnical Study
EXPLANATION
B204689 Background (Deep) Bedrock Monitoring Wells
B405586 Background Rocky Flats Alluvium and Colluvium Monitoring Wells
B400389 Background Borewells
B405489 Shallow Bedrock Monitoring Wells
B402689 Valley Fill Alluvial Monitoring Wells
B304389 Abandoned Location
SED17/SW41 Surface Water Sampling Station and Sediment Sampling Station
0 500 1000 Feet
CONTOUR INTERVAL = 20'
N
SED22/SW04
B202589
B201289
B201389
B202489
SED21/SW108
B201489
B204189
B201089
B204089
B204689
B102389
B102289
SED20/SW05
SED23/SW06
SED04/SW07
B402689
SED16/SW107
SED17/SW41
B405289
B405789
B405989
B405889
B402189
SED18/SW80
B401989
SED19/SW104
B405586
B405489
B400189
B400089
B400289
B400389
B405689
B405789
B400489
B304789
B301889
B302389

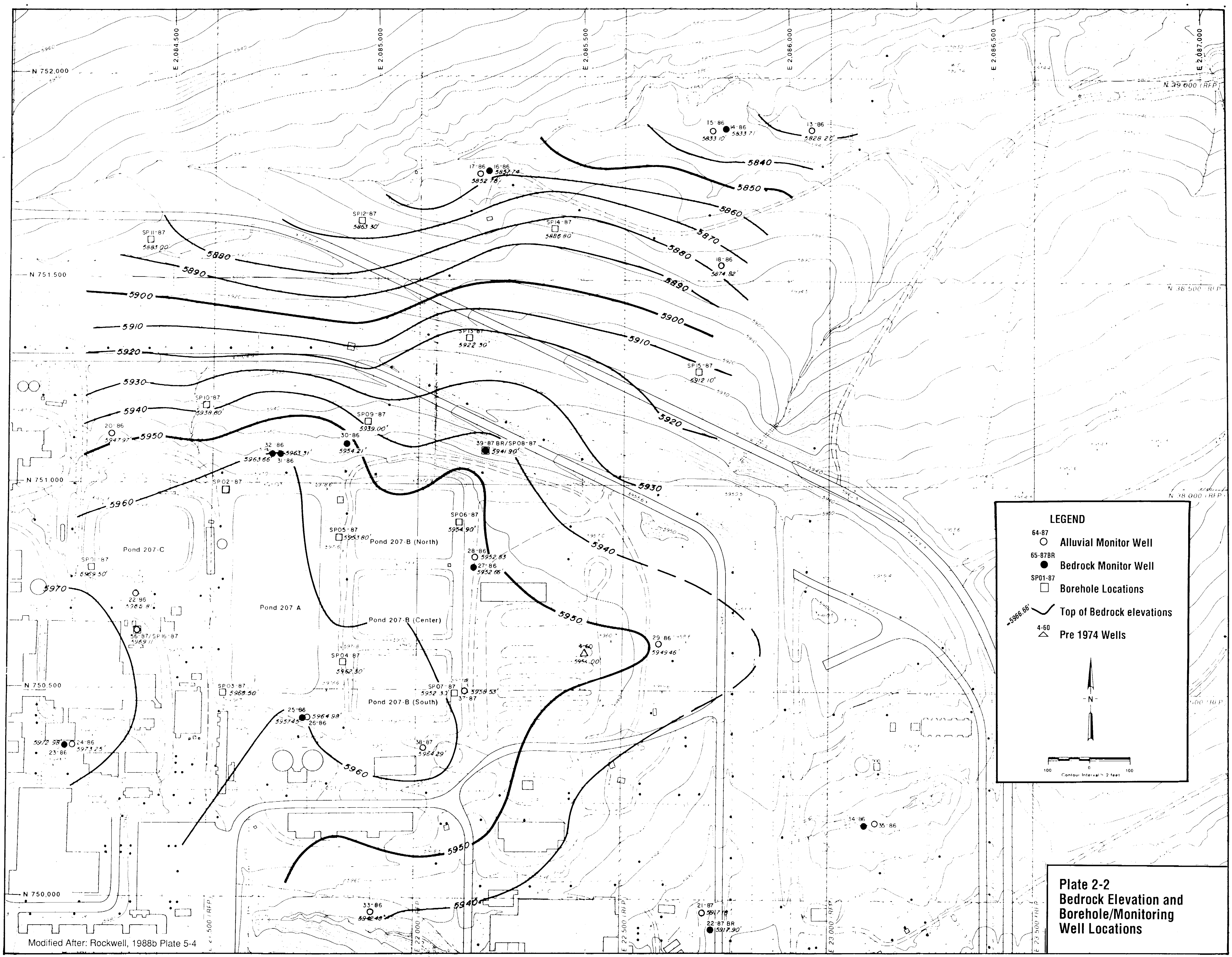


Plate 2-2
Bedrock Elevation and Borehole/Monitoring Well Locations

Modified After: Rockwell, 1988b Plate 5-4

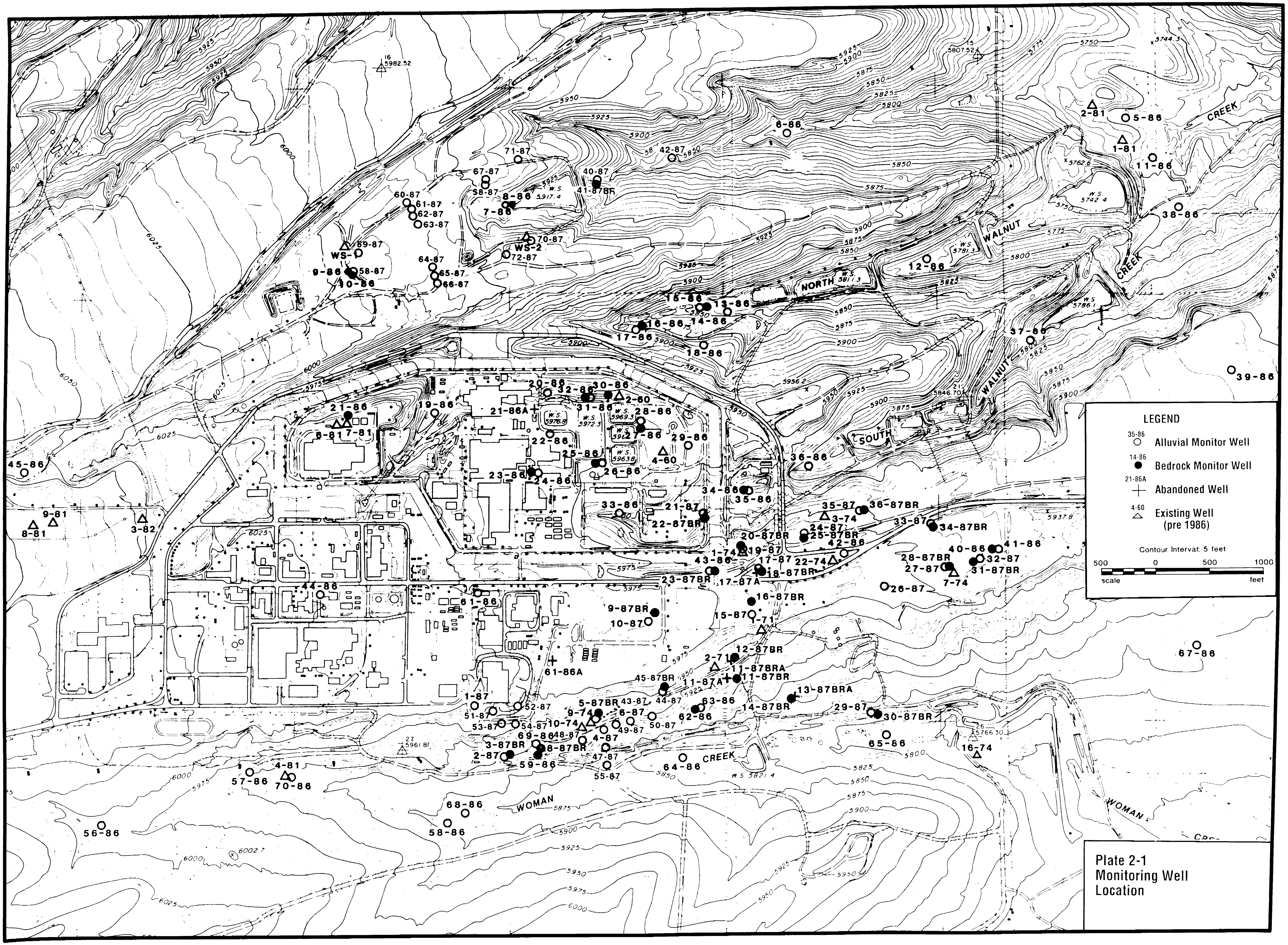


Plate 2-1
Monitoring Well
Location